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An Internet-of-Things (IoT) System for Smart Farming and Environmental Management

Ismail Salisu[1], Jabiru Abdullahi[2], Aminu Sulaiman Usman[3]

Department of Computer Science, Federal Polytechnic Daura, P.M.B. 1049, Katsina State, Nigeria[1-3]

Abstract: Over decades, agriculture has seen tremendous revolution. The development of farm machineries such as tractors, harvesters, improved irrigation systems have contributed immensely to food security and sustainable economy. The development of Computers has contributed significantly in improving our daily activities, and agriculture is not an exception.

New technology called Internet of Things (IoT) is bringing to light amazing developments in process automation, process control, data collection, and real-time response to events. It has helped in home automation, self-driving cars, Unmanned Aerial vehicles and many more.

IoT can be applied in agriculture by means of sensors aimed at field monitoring, disease detection; temperature, humidity and soil moisture monitoring, automatic irrigation system, IoT based drones, farm animals monitoring etc.

The change of climate in the Sahel, caused largely by global warming and desertification, has affected so much of production and farm output**, we aim in this research** to apply IoT technology in climate monitoring such as the temperature and humidity, soil moisture monitoring, crop management, precision farming practice, , farm management using End-to-End Farm Management System.

The result shows an interesting output of the variations in temperature, humidity, soil moisture, sunlight levels and probable rain drops in the experiment site.

The result were shown directly on the LCD screen attached to the Arduino microcontroller and at the same time transmitted over the internet to the IoT cloud and displayed on the Arduino IoT remote application. This research was implemented on a small part on an irrigation site and can thus be expanded to accommodate larger components for use on large farm site.

Keywords: Internet-of-things (IoT), Sensors, Cloud, Irrigation and Farming, Arduino

I. INTRODUCTION

Many challenges hinder agricultural production, leading to a decline in crop productivity which in turn leads to food scarcity and social insecurity; such challenges include lack of environmental control, lack of farm monitoring, statistics of farm data variations etc. (Bamigboye F. and Emmanuel O. 2016).

The recent changes especially in the climate and desertification, have made a significant effect on the agricultural output in the sahelian part of northern Nigeria, Climate-related threats like the recent extended dry seasons, floods, and soil degradation are more common and severe, posing a serious threat to agricultural livelihoods and food security (UNDP, 2022). This has made researchers from different fields to explore ways of mitigating and bringing to light a sustainable food production for the country.

Computers can be applied to study and monitor farm activities such predicting weather, pest and diseases control, crop management (when to and when not to take certain decisions), general monitoring and evaluation of farm activities by using sensors to send notifications or alert risk in real time or as of when due. Applying these technologies gave helped other parts of the world to increase production and reduce loss risk.

The Internet of Things (IoT) is the network of physical objects or things embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data (James D., 2018). The data generated can be used by the devices for automatic action or it can be transmitted over the internet to the user for appropriate response and decision making.

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With IoT It is believed that there are more devices connected to the internet than the population of human beings on earth. According to Statista, there are over 15 billion connected IoT devices online. Developed countries have adopted the IoT as a major contributor in process automation, data gathering, vehicular movement and monitoring, home automation, security and safety, health monitoring, and agriculture has never been an exception.

IoT has been applied in Agricultural field in many instances, such as the application of IoT in farm monitoring, ripe fruits identification, irrigation, drones as sprayers and security watch and many more (TeleSense, 2017). A report by Machina stated that connected agricultural devices are expected to grow from 13 million in 2014 to 225 million in 2024.

IoT is also contributing significantly in the field of agriculture in areas such as animal monitoring (smart animals), soil texture monitoring, smart gardening, connected tractor, storage monitoring, farm products tracking systems etc.

Application of IoT in Northern Nigeria can help in monitoring vital information such as the temperature and humidity using sensors, use satellite images to monitor farm activities from remote locations, precision farming practice by determining the amount of water and/or fertilizer needed by crops which will in turn ensure resource management, silos management, spray using drones and easy identification of affected areas (FAO, 2019).

II. LITERATURE REVIEW

Farmers in northern Nigeria have been using traditional farm management methods; this has continued to impede agricultural development and production; whereas the smart agricultural solution is continuing to gain popularity among developed countries and the local agricultural producers cannot satisfy the demands of the constantly growing population of the country (Nina G, 2020).

IoT is continuing to get significance in the field of agriculture, this has been possible by observing the impact it has made and the improvement of devices designed to achieve this aim.

So many literatures have been written extensively, highlighting the relevance of IoT in farm management and productivity increase. Few of these are:

1. Ali M, Reza MN, Kiraga S, Islam MN, Chowdhury M, Jeong JH, Chung SO. Construction and basic performance test of an ICT-based irrigation monitoring system for rice cultivation in UAE desert soil. In this research they design an irrigation monitoring system for rice cultivation using drip and micro-sprinkler irrigation and tested it in desert soils using a Raspberry Pi. A data acquisition system was developed using the Raspberry Pi to control the irrigation and to monitor the soil water content, ambient temperature, humidity, and light intensity inside the net house. Another sensor-based automatic irrigation logic circuit was used to control actuators and to manage crop irrigation operations depending on the soil water content requirements.

2. A system with modules for GPS based remote controlled monitoring, moisture & temperature sensing, intruders scaring, security, leaf wetness etc. was developed by (Suma N. et'al. 2017). the system uses wireless sensor networks continuous check on the soil properties and environmental factors the data is then transmitted via wifi to a cloud storage for action by the farm manager.

3. R. S. Kawitka and Nikesh Gondchawar developed an "IOT Based Smart Agriculture Monitoring System" with smart GPS based remote controlled robot that perform tasks such as weeding, spraying, moisture sensing, bird and animal scaring; it also merged smart irrigation with smart control and intelligent decision making based on real time field data. The system has a smart warehouse management which includes temperature maintenance, humidity maintenance and theft detection in the warehouse

4. Ioana Marcu et'al 2019 designed an IoT based System for Smart Agriculture. The solution was made to provide information on plant growth, crops' diseases, and soil properties that are a benefit for crops.

In this research we're going to focus our effort towards developing a system for monitoring farm and environmental condition in an irrigation site at Daberan Irrigation site in Daura Local Government, Katsina State, Nigeria.

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III. METHODOLOGY

In this research we proposed and developed an IoT model for monitoring an irrigation farm and executing certain functionalities with the system.

The monitoring functionalities are as follows:

i. Temperature variation at the site

ii. Humidity of the environment as it relates to water retention in plants and indirectly affects the growth of leaves, photosynthesis, pollination, and probability of disease contact by the plants.

iii. Soil moisture level.

iv. Water level measurement: this is to determine the amount of water present in each irrigation column during watering of the farm.

v. Photo resistor or sunlight measurement.

The functionalities we want the system to perform are as follows:

a. Display the different sensors reading on an LCD display that is directly connected to the microcontroller board.

b. Transmission of live data on the Arduino remote IoT app.

c. Blink continuously, a RED LED light at highest temperature to alert the farmer take appropriate action.

d. Blink continuously, a GREEN LED when soil moisture level is <20%.

e. Beeps an alarm when the water level in a column reached the maximum gauge.

f. ON a submersible pump when the soil moisture is <20%.

Major materials used in the system development

S/N	NAME	DESCRIPTION	SPECIFICATIONS
1.	Arduino Uno Microcontroller		• ATmega328P 16 MHz, 2KB SRAM, 32KB FLASH, 1KB EEPROM • 14 I/O pins • 6 analog inputs • 16 MHz ceramic resonator • USB connection • Power jack. • LED

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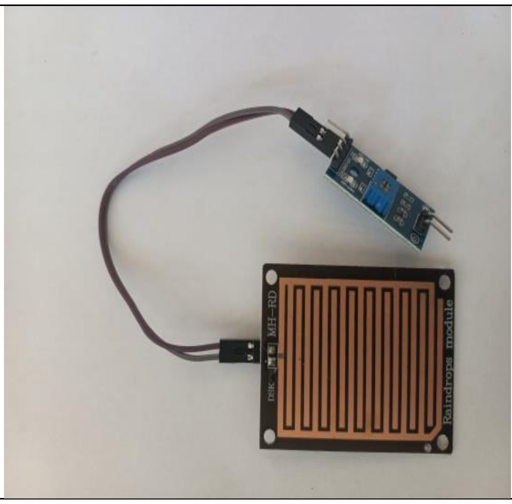
2.	Soil moisture sensor		• VCC: .3 V-5V • GND: GND • DO: digital output interface (0 and 1) • AO: Analog Output Interface
3.	Temperature and humidity Sensor		• VCC(3V to 5V) • GND • AO (Analog Output) • Digital Output (TTL levels)
4.	Rain Sensor		• VCC(3V to 5V) • GND • AO (Analog Output) • Digital Output (TTL levels)
5.	Sunlight sensor		• Bright 5-10KΩ • Dark 0.2MΩ

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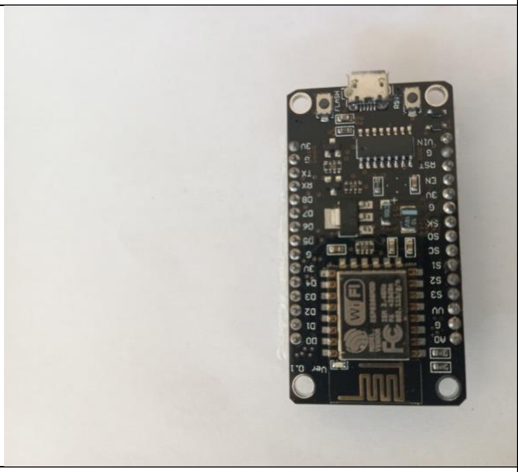
6.	Water level sensor		• power supply: 5V • Operating current: <=20mA
7.	GPRS module		• Quad-Band 850 / 900/ 1800 / 1900 MHz • GPRS multi-slot class 10/8 • GPRS mobile station class B Compliant to GSM phase 2/2+ • Class 4 (2 W @ 850 / 900 MHz) Class 1 (1 W @ 1800 / 1900MHz) • power consumption - 1.5Ma
8.	Node MCU Wi-Fi module		• 32-bit RISC CPU Xtensa LX106 • Operating Voltage: 3.3V • Input Voltage: 7-12V • Digital I/O Pins (DIO): 16 • Analog Input Pins (ADC): 1 • Flash Memory: 4 MB • SRAM: 64 KB • Clock Speed: 80 MHz
9.	Submersible pump		• power supply: 2.5 ~ 6V • current consumption: 220Ma

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10.	Relays		• Power supply: 5v
11.	Power module		Power over USB

In this system the sensors were connected each to the analog and digital I/O ports on the microcontroller. Figure 1 describes the system design layout and figure 2 defined the microcontroller circuitry diagram.

i. The soil moisture sensor was connected to the A0 analog input on the Arduino microcontroller; the readings were processed and displayed on the LCD display with the label "**SM".** The moisture was displayed in % levels at different intervals of 10 minutes.

ii. The water level sensor was used to test the water available in each of the irrigation columns on the experiment site. This sensor serves the purpose of determining the amount of water transferred to each of the columns according to their sizes. The water level is then displayed on the LCD in terms of litres poured through the vessel in each minute. This is calculated by taking a constant amount of water flowing through the irrigation engine per minute. The water level is displayed right on the LCD denoted with letter **"W".**

iii. Temperature and humidity: denoted as **"T&H"** on the display, the temperature variation is displayed at 10 minutes interval in **"^{0}C"** the humidity is displayed in %. When the temperature exceeded 45^{0}c a red LED with start blinking at 3 seconds interval.

iv. The rain sensor determines when there's a rainfall or huge water flow in the irrigation columns. When sensor is activated a green LED light was automated to blink at 2 seconds interval to signal rainfall or rain drops in the field.

v. The sunlight sensor measures the percentage of sunlight in the field. The sunlight is very critical in photosynthesis, and plant growth monitoring.

vi. The submersible water pump: since this is a mini project, the submersible pump was used to display the urgent need of water in an irrigation column; this is made possible by determining the soil moisture level. When the SM<20% the submersible pump relay will trigger the pump to release water from the water container it's dipped in.

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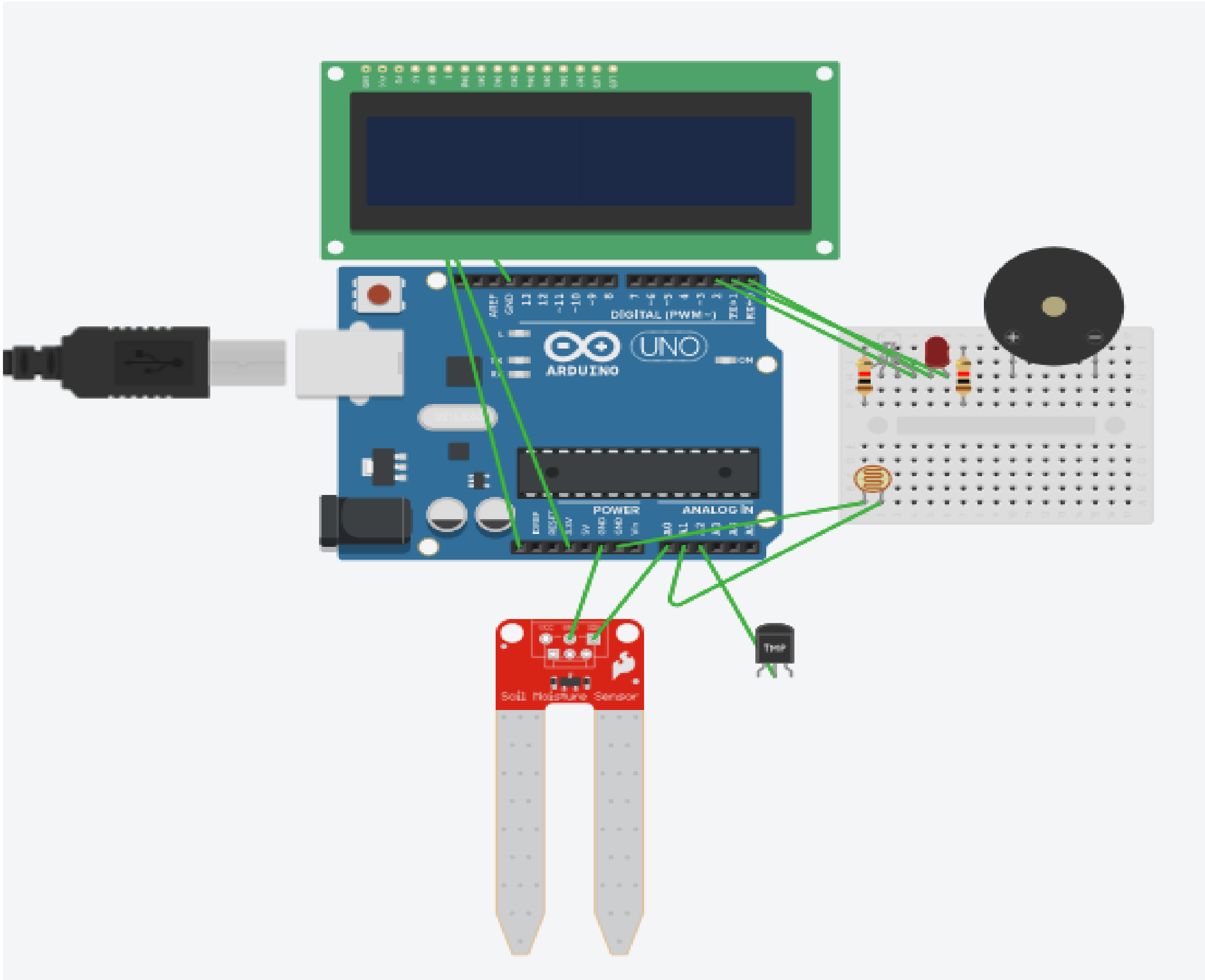

Figure 1: System design layout

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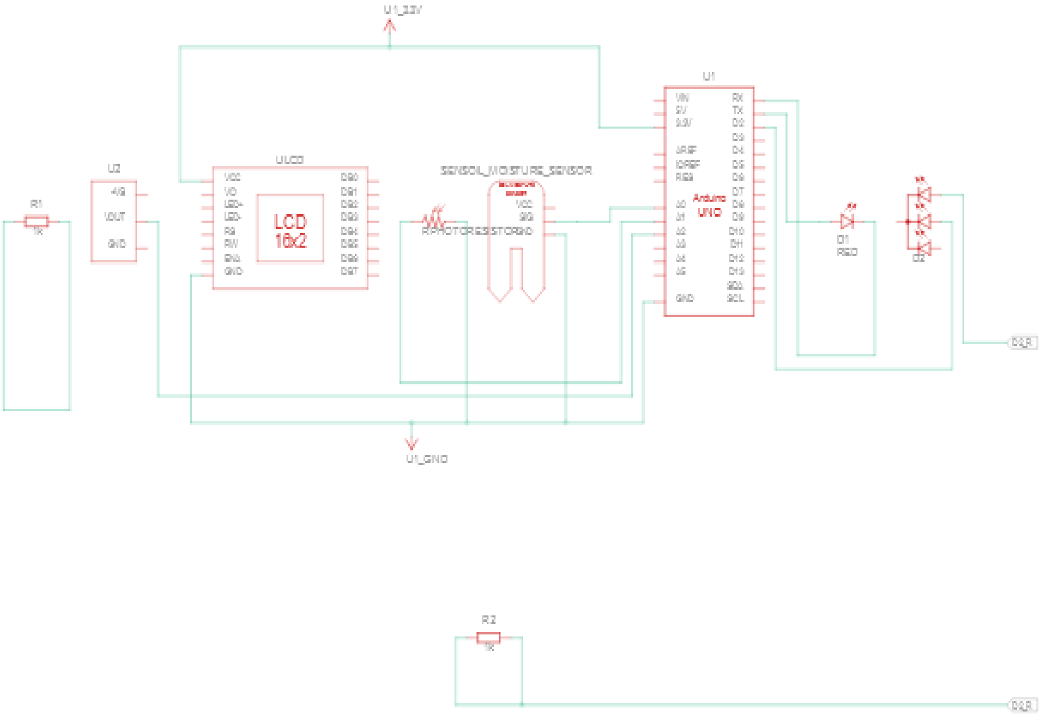

Figure 2: circuitry design

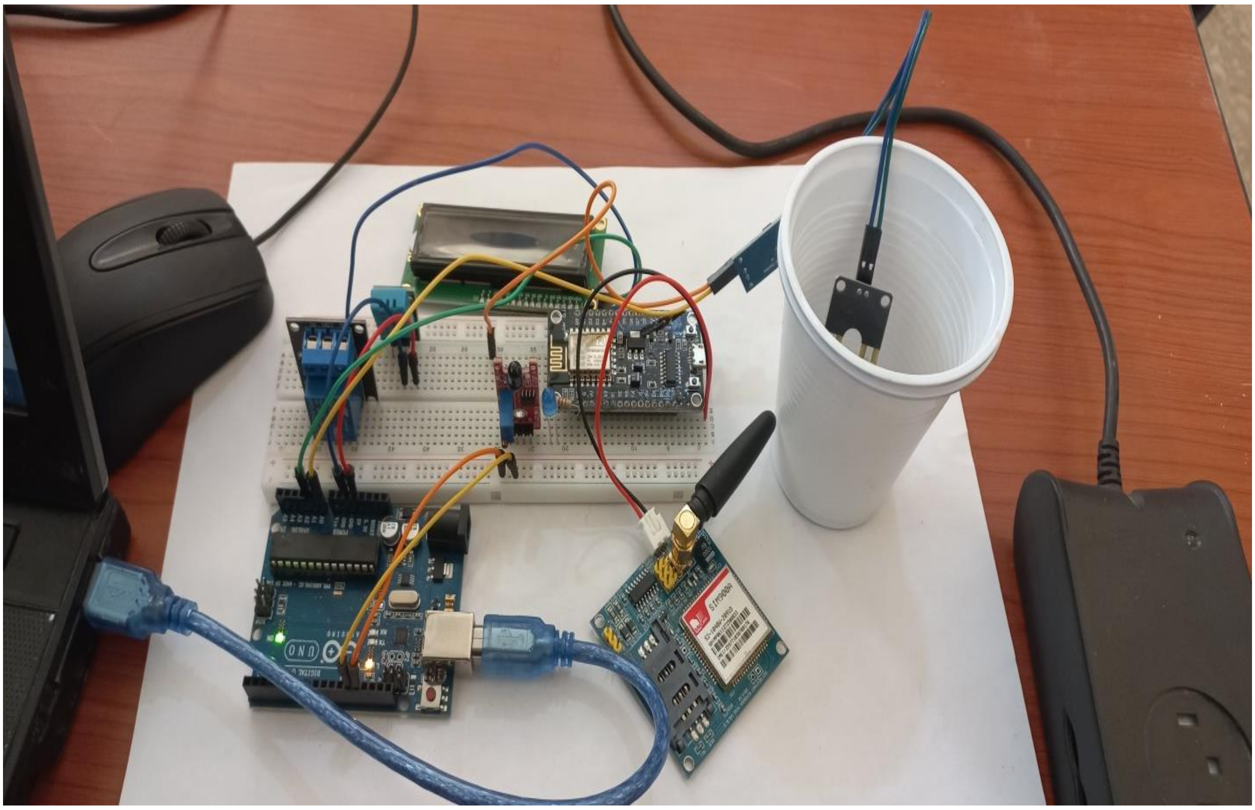

Figure 3: System design

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Data transmission

The system is composed of sensors for data collection and a set of communication components such as the node MCU Wi-Fi module and a GPRS module for SMS communication to the client's device.

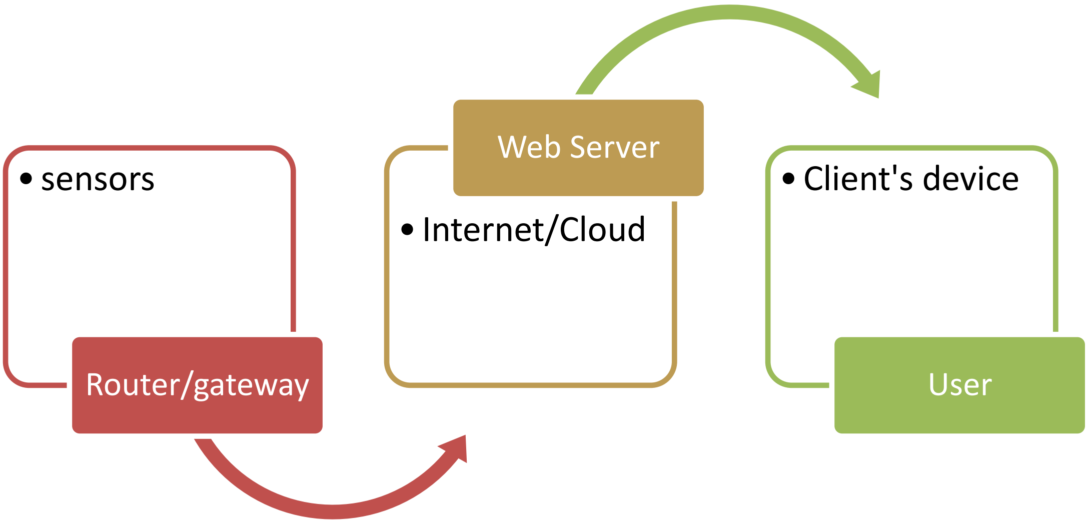

Figure 4: IoT data flow

IV. RESULTS AND CONCLUSION

This system has presented an easiest modern method of farm monitoring and an overall environment monitoring. The system displayed real time data variation of temperature, humidity, soil moisture, raindrops, water level, sunlight intensity etc.

on the LCD display connected to the microcontroller and a real time data on the Arduino IoT cloud. This system proves simple and efficient with composition of simple modules for data collection, transmission and action.

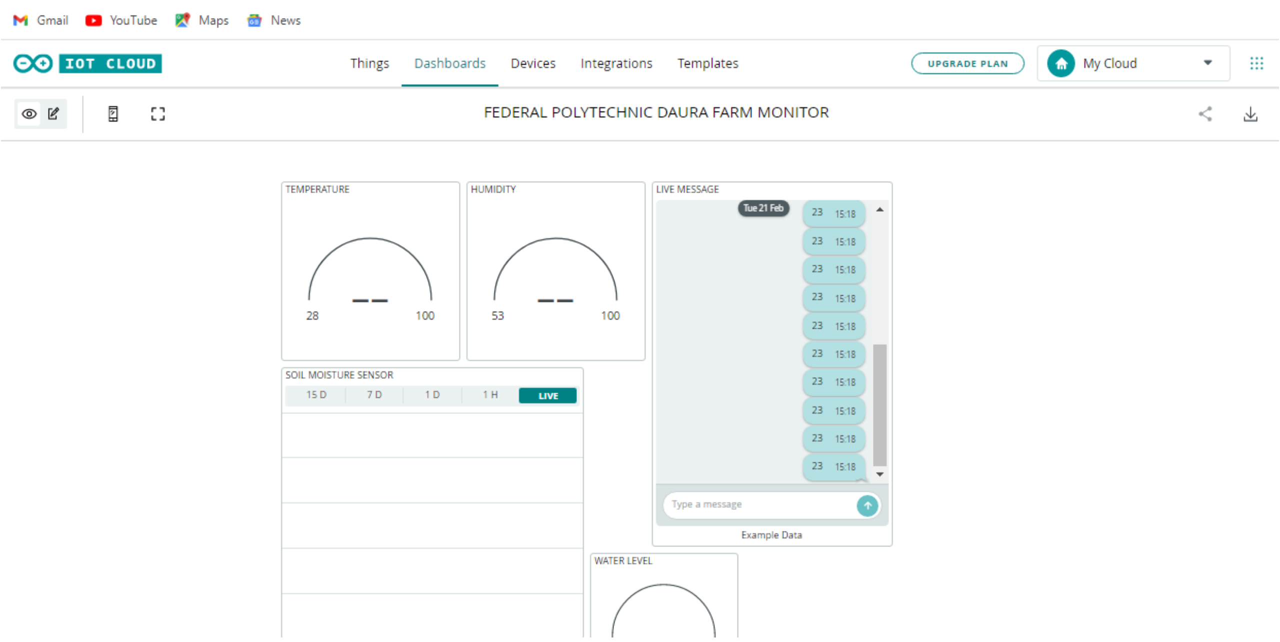

Figure 5: IoT cloud live data page

Recommendations for future work

1. Developing a a more multipurpose system with additional components.
2. Testing the system on a larger agricultural land
3. Developing a server system on the microcontroller
4. Short-range communication support

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