A Smart Framework for Agriculture Production Improvement using Web of Things

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***Abstract* — Internet of Things (IoT) has revolutionized many fields in the recent past. It addresses many aspects related to the data management, storage and connectivity. This work will focus on the application of IoT to automatic irrigation system. The system will use a microcontroller, preferably of 32-bit. Microcontroller uses wireless sensor nodes placed in the farm and collects information such as temperature, soil moisture, water level, pressure, humidity. This information gathered is then stored on cloud. Microcontroller uses a WiFi module connected in station mode. The WiFi module establishes a connection to a router and posts the data periodically to the cloud. It uses the common IEEE 802.11 standard protocol stack for communication between device and the internet. Data transmitted to the cloud can be used to control the irrigation. The system can be further extended to alert the farmer to take necessary steps according to the weather parameters. Lolin Node MCU is used as the Microcontroller. Node MCU uses ESP8266 wifi module which uses Tensilica's L106 Diamond series 32-bit processor, with on-chip SRAM, besides the WiFi functionalities. The GPIO pins of the ESP8266 can be used to interface sensor nodes*.

Keywords — *Internet of Things (IoT)*

I. INTRODUCTION

The world is facing new challenges in this transition stage, where problems like global warming and alternative energy sources are of major concerns. Sustainable development is important rather than economic growth. In the past environmental, social and economic aspects are viewed as separate entities but they are presently viewed as a combined entity.Good governance must promote policies with sustainability in all sectors such as manufacturing, agriculture, and services. Climatic change, population growth and hunger occur because of the depletion of natural resources. To successfully address some of these issues, we need multidisciplinary approaches.

Agricultural production and cultivation has a significant impact in filling the basic human need for food. Income can be generated from production, preparation, packaging and distribution of food.

II. LITERATURE SURVEY

A. *Existing system*

The effectiveness of an agricultural system is basically depends on the accurate set of real-time measurements. In [1], parameters such as soil condition and humidity are taken over a longer periods. This data is aggregated and analyzed. The useful information after the analysis is conveyed to the farmer for guidance. This can be applied for automated procedures to the crop cultivation process chain also.

In [2], a wireless multi-function custom platform was developed. It is a custom Printed Circuit Board (PCB) that is designed as easy to use platform that contains ATMega128 microcontroller. This controller can host operating systems such as Contiki or TinyOS. This board also contains an on-board IEEE802.15.4 with a high performance built-in antenna that can achieve a range of 300m in line-of-sight conditions when the output power is 3mW.

In [3], authors proposed a smart Agriculture System (AgriSys) that can analyze an environment and intervene to maintain its adequacy. The system uses inference rules which can be upgraded easily and controls the agricultural environment. It takes care of soil pH, temperature and humidity inputs. The system is all weather compliant and works well in desert-specific weather such as dust, sandy soil, wind direction, low humidity. It can also withstand diurnal and seasonal temperatures. The system developed was ubiquitous and provides distance access with enhanced safety, and increased productivity.

III. INTERNET OF THINGS

The Internet of Things (IoT) is the interconnection of uniquely identifiable embedded computing devices within the existing Internet infrastructure. Internet of Things represents a general concept for the ability of network devices to sense and collect data from the world around us, and then share that data across the Internet where it can be processed and utilized for various interesting purposes. Some also use the term *industrial Internet* interchangeably with IoT. This refers primarily to commercial applications of IoT technology in the world of manufacturing. The Internet of Things is not limited to industrial applications. Some future consumer applications envisioned for IoT sound like science fiction, but some of the more practical and realistic sounding possibilities for the technology include:

A. *receiving warnings on your phone or wearable device when IoT networks detect some physical danger is detected nearby*

B. self-parking automobiles

C. automatic ordering of groceries and other home supplies

D. automatic tracking of exercise habits and other day-to-day personal activity including goal tracking and regular progress reports

E. Potential benefits of IoT in the business world include:

F. location tracking for individual pieces of manufacturing inventory

G. fuel savings from intelligent environmental modeling of gas-powered engines

H. new and improved safety controls for people working in hazardous environments

A. *Iot Communication Models*

Internet of Things Communications Models From an operational perspective, it is useful to think about how IoT devices connect and communicate in terms of their technical communication models. In March 2015, the Internet Architecture Board (IAB) released a guiding architectural document for networking of smart objects (RFC 7452), which outlines a framework of four common communication models used by IoT devices. The discussion below presents this framework and explains key characteristics of each model in the framework.

A. Device-To-Device Communications

The device-to-device communication model represents two or more devices that directly connect and communicate between one another, rather than through an intermediary application server. These devices communicate over many types of networks, including IP networks or the Internet. Often, however these devices use protocols like Bluetooth, Z-Wave, or ZigBeeto establish direct device-to-device communications, as shown in Fig 1

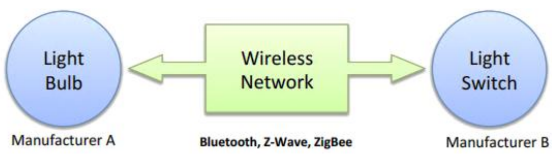

Figure1: Example of device-to-device communication model.

B. Device-To-Cloud Communications

In a device-to-cloud communication model, the IoT device connects directly to an Internet cloud service like an application service provider to exchange data and control message traffic. This approach frequently takes advantage of existing communications mechanisms like traditional wired Ethernet or Wi-Fi connections to establish a connection between the device and the IP network, which ultimately connects to the cloud service. This is shown in Fig 3.2.

Figure 2. Device-to-cloud communication model diagram.

This communication model is employed by some popular consumer IoT devices like the Nest Labs Learning Thermostat and the Samsung SmartTV. In the case of the Nest Learning Thermostat, the device transmits data to a cloud database where the data can be used to analyze home energy consumption. Further, this cloud connection enables the user to obtain remote access to their thermostat via a smartphone or Web interface, and it also supports software updates to the thermostat. This is commonly referred to as "vendor lock-in'', a term that encompasses other facets of the relationship with the provider such as ownership of and access to the data. At the same time, users can generally have confidence that devices designed for the specific platform can be integrated.

C. Device-To-Gateway Model

In the device-to-gateway model, or more typically, the device-to-application-layer gateway (ALG) model, the IoT device connects through an ALG service as a conduit to reach a cloud service. In simpler terms, this means that there is application software operating on a local gateway device, which acts as an intermediary between the device and the cloud service and provides security and other functionality such as data or protocol translation. The model is shown in Figure 3. 3.

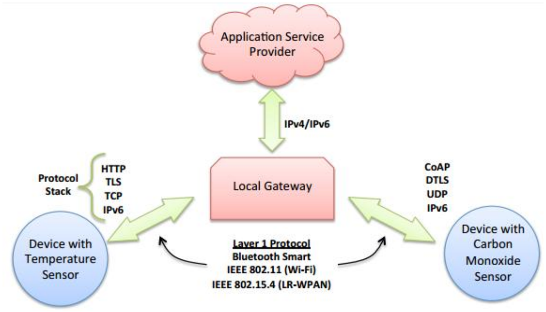

Figure 3. Device-to-gateway communication model diagram.

Several forms of this model are found in consumer devices. In many cases, the local gateway device is a smartphone running an app to communicate with a device and relay data to a cloud service. This is often the model employed with popular consumer items like personal fitness trackers. These devices do not have the native ability to connect directly to a cloud service, so they frequently rely on smartphone app software to serve as an intermediary gateway to connect the fitness device to the cloud.

D. *Back-End Data-Sharing Model*

The back-end data-sharing model refers to a communication architecture that enables users to export and analyze smart object data from a cloud service in combination with data from other sources. This architecture supports "the [user's] desire for granting access to the uploaded sensor data to third parties". This approach is an extension of the single device-to-cloud communication model, which can lead to data silos where "IoT devices upload data only to a single application service provider''. A back-end sharing architecture allows the data collected from single IoT device data streams to be aggregated and analyzed. The back-end data-sharing model suggests a federated cloud services approach or cloud applications programmer interfaces (APIs) are needed to achieve interoperability of smart device data hosted in the cloud. A graphical representation of this design is shown in Figure 3.4.

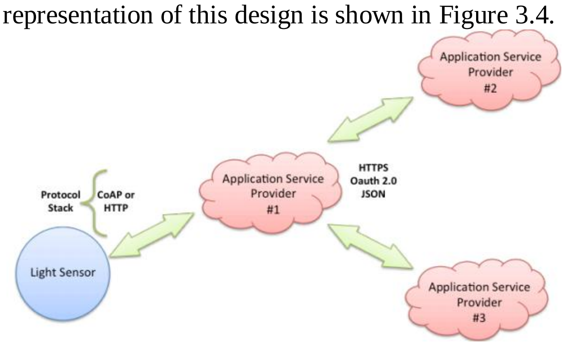

Figure 4. Back-end data sharing model diagram.

This architecture model is an approach to achieve interoperability among these back-end systems. As the IETF Journal suggests, "Standard protocols can help but are not sufficient to eliminate data silos because common information models are needed between the vendors." In other words, this communication model is only as effective as the underlying IoT system designs. Back-end data sharing architectures cannot fully overcome closed system designs. Internet of Things Communications Models Summary The four basic communication models demonstrate the underlying design strategies used to allow IoT devices to communicate.

IV. SYSTEM OVERVIEW

The system we are developing will focus on the application of IoT to automatic irrigation system. The system will use a microcontroller, preferably of 32-bit. Microcontroller uses wireless sensor nodes placed in the farm and collects information such as temperature, soil moisture, water level, pressure, humidity.

This information gathered is then stored on cloud. Microcontroller uses a Wi-Fi module connected in station mode. The Wi-Fi module establishes a connection to a router and posts the data periodically to the cloud. It uses the common IEEE 802.11 standard protocol stack for communication between device and the internet. Data transmitted to the cloud can be used to control the irrigation. The system can be further extended to alert the farmer to take necessary. The overall system design is shown in Fig. 4.1.

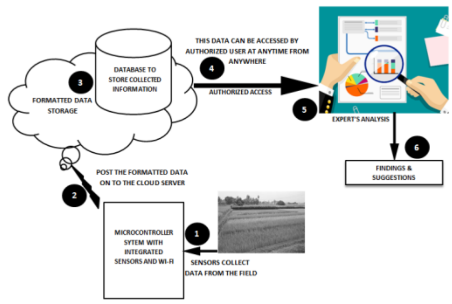

Figure 5. Overall System View

Fig 4.1 shows the block diagram of the system. As we can see, there is a microcontroller to which we have sensors attached in the field. These sensors are used to measure

1. Soil pH value
2. Soil Moisture Content
3. Ground and Surface Water Levels
4. Temperature and Humidity

The entire setup is installed at a farm. The sensors collect the data from the installed farm and give this data to the microcontroller. The microcontroller will process this data and formats this into a suitable packet that can be used to post data. The server on the cloud handles this data and stores it in the form of data value table. An expert or any authorized user can access this data using a key and make analysis on the data in order to give suggestions to the farmer based on the analyzed data.

A. *HARDWARE*

1) *ATMEGA2560*

Arduino Mega 2560 board.Built on the Atmel ATmega2560 microcontroller and USB-UART interface chip CH340G.Board for functionality similar to the Arduino Mega 2560. It is a budget, but the same stable, and uses the original chips ATmega2560 (16 MHz). The board used the chip CH340G as converter UART-USB. Chip CH340G - is a budget solution. When you work in the frequency 12Mhz, giving a stable result of data exchange (need install drivers to computer).

Mega 2560 CH340G / ATmega2560 - connects to the computer via micro USB cable (used for almost all Android smartphones). You can supply power to board through the MicroUSB connector or DC Barel Jack power connector. The voltage regulator (LDO) can deal with incoming voltage from 6V to 12V (peack 18V) DC. Output current for 5V - about 800mA, for 3.3V - about 180mA (Please note that the higher the input voltage the lower the outgoing current). That will provide a reliable power most of your initial projects. * On photo board new version of 2016 year. Is different from old version.

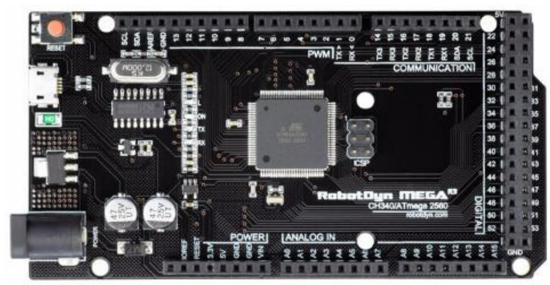

Figure 6. MEGA2560 Microcontroller Board

The technical specifications of MEGA2560 are given in Table 1.

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

Table 1. MEGA2560 SpecificationS

2) *Soil Moisture Sensor*

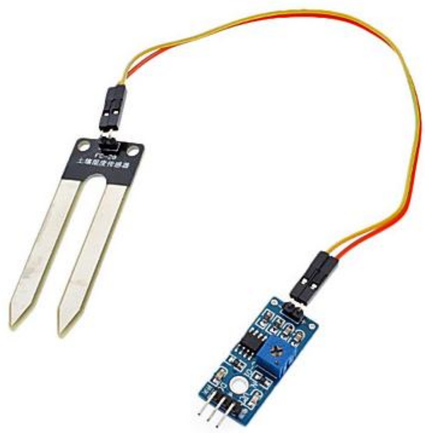

Figure 7. Soil Moisture Sensor

Fig 4.2 shows the soil moisture sensor. This Moisture Sensor can be used for detecting the moisture of soil or judge if there is water around the sensor, let the plant in your garden able to reach out for human's help when they are thirsty. This sensor is very easy to use, you can just simply insert in into the soil and read the data. The Soil Moisture Sensor uses capacitance to measure the water content of soil (by measuring the dielectric permittivity of the soil, which is a function of the water content). Simply insert this rugged sensor into the soil to be tested, and the volumetric water content of the soil is reported in percent.

- Range: 0 to 45% volumetric water content in soil (capable of 0 to 100% VWC with alternate calibration)
- Accuracy: ±4% typical
- Typical Resolution: 0.1%
- Power: 3 mA @ 5VDC
- Operating temperature: –40°C to +60°C

By reading the current between the two electrodes changes, the sensor using two probes, the current through the soil, and then reads the resulting moisture content of the resistor. More in the case of water, the soil more easily power (decrease resistance), and dry soil poor electrical conductivity (resistance).The sensor surface made of metal processing, can extend its life. Insert it into the soil, and then read it using the AD converter.

3) Soil pH Sensor

Fig 4.3 shows the soil pH sensor which is used to measure the soil nature. Plant roots absorb mineral nutrients such as nitrogen and iron when they are dissolved in water. If the soil solution is too acid or alkaline, some nutrients won't dissolve easily, so they won't be available for uptake by roots.

Figure 8. Soil pH Sensor

Most nutrients that plants need can dissolve easily when the pH of the soil solution ranges from 6.0 to 7.5. Below pH 6.0, some nutrients, such as nitrogen, phosphorus, and potassium, are less available. When pH exceeds 7.5, iron, manganese, and phosphorus are less available.Many environmental factors, including amount of rainfall, vegetation type, and temperature, can affect soil pH. In general, areas with heavy rainfall and forest cover moderately acid soils. Soils in regions with light rainfall and prairie cover near neutral. Droughty areas tend to have alkaline soils. However, the pH of cultivated and developed soils often differs from that of native soil, because during construction of homes and other buildings, topsoil is frequently removed and may be replaced by a different type of soil.

4) Sht25 Temperature And Humidity Sensor

The SHT25 high accuracy humidity and temperature sensor of Sensiron has become an industry standard in terms of form factor and intelligence: Embedded in a reflow solderable Dual Flat No leads (DFN) package of 3 x 3mm foot print and 1.1mm height it provides calibrated, linearized sensor signals in digital, I2C format. The SHT2x sensors contain a capacitive type humidity sensor, a band gap temperature sensor and specialized analog and digital integrated circuit – all on a single CMOSens® chip. This yields in an unmatched sensor performance in terms of accuracy and stability as well as minimal power consumption.

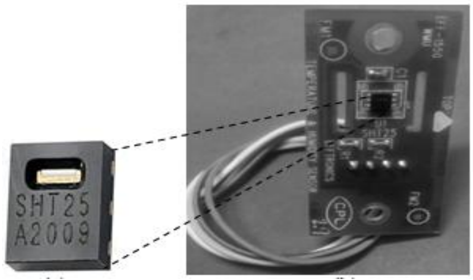

Figure 9. SHT25 and Adaptor board

Every sensor is individually calibrated and tested. Lot identification is printed on the sensor and an electronic identification code is stored on the chip – which can be read out by command. Furthermore, the resolution of SHT2x can be changed by command (8/12bit up to 12/14bit for RH/T) and a checksum helps to improve communication reliability. With this set of features and the proven reliability and long-term stability, the SHT2x sensors offer an outstanding performance-to-price ratio. For testing SHT2x two evaluation kits EK-H4 and EK-H5 are available.

The relative temperature is calculated by the following formula.

$$T = -46.85 + 175.72\frac{S_T}{2^{RES}}$$

where S_T is the temperature signal, RES is the resolution between 8 -12-bits.

The relative humidity is calculated as

$$RH = -6 + 125\frac{S_{RH}}{2^{RES}}$$

where, S_{RH} is the signal from the relative humidity and RES is resolution between 12-14 .

5) Hcsr-04 Ultrasonic Sensor

The ultrasonic sensor is used as level detector in this system. The system measures two levels namely, Ground Water Levbel (GWL) and Surface Water Level (SWL). The surface water level indicates the amount of water level that must be maintained above the ground for a crop. The ground water level indicates the amount of water present inside the Earth. The average ground water level in Southern India is 7m. The ultrasonic sensor maximum range is 4m. so what we have done to measure the ground water level is we have attached the sensor to a 4m wire so that the total ground level is equal to the sum of 4m and the reading from the ultrasonic sensor.

Figure 10. HCSR – 04 Ultrasonic Sensor.

B. *SOFTWARE*

1) ARDUINO IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Programs written using Arduino Software (IDE) are called **sketches**. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor. Versions of the Arduino Software (IDE) prior to 1.0 saved sketches with the extension .pde. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .ino extension on save.

Verify
Checks your code for errors compiling it.

Upload
Compiles your code and uploads it to the configured board. See uploading below for details.
Note: If you are using an external programmer with your board, you can hold down the "shift" key on your computer when using this icon. The text will change to "Upload using Programmer"

New
Creates a new sketch.

Open
Presents a menu of all the sketches in your sketchbook. Clicking one will open it within the current window overwriting its content.
Note: due to a bug in Java, this menu doesn't scroll; if you need to open a sketch late in the list, use the **File | Sketchbook**menu instead.

Save
Saves your sketch.

Serial Monitor
Opens the serial monitor.

Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.

2) Thingspeak Cloud

In order to send data on cloud we need a server. Thing Speak server allows users to upload sensor data upto 50 MB free of cost. Thing Speak is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. Thing Speak provides instant visualizations of data posted by your devices to Thing Speak. With the ability to execute MATLAB® code in Thing Speak you can perform online analysis and processing of the data as it comes in. Some of the key capabilities of Thing Speak include the ability to:

- Easily configure devices to send data to ThingSpeak using popular IoT protocols.
- Visualize your sensor data in real-time.
- Aggregate data on-demand from third-party sources.
- Use the power of MATLAB to make sense of your IoT data.
- Run your IoT analytics automatically based on schedules or events.
- Prototype and build IoT systems without setting up servers or developing web software.
- Automatically act on your data and communicate using third-party services like Twilio® or Twitter®.

V. RESULTS

The data from the sensors is posted to the ThingSpeak server. The server provide facility of Graphical display of the sensor data over time.

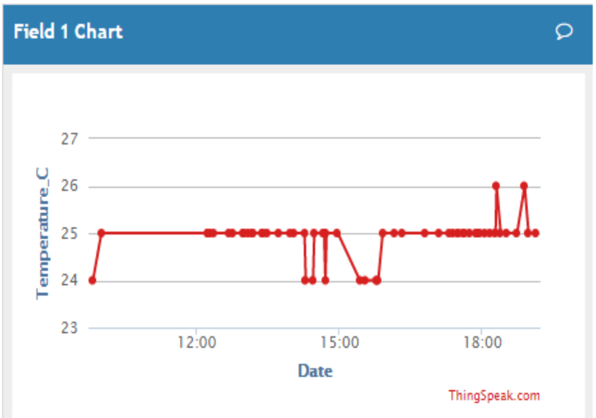

Figure 11. Temperature Variations

Figure 11. shows the variation of temperature over time. The sensor has a tolerance of ±0.5^{0}C.hence these readings are highly accurate.

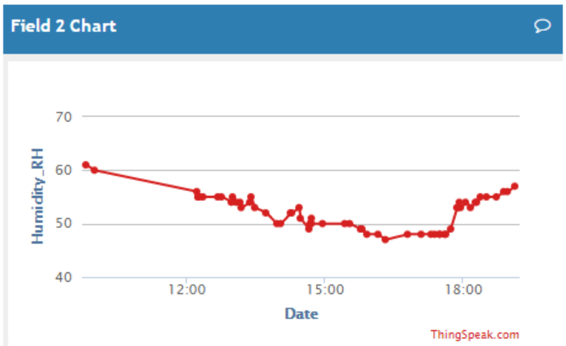

Figure 12. Humidity Variations

The variation of humidity in terms of %RH is shown in Fig 5.2. The %RH calculation has a tolerance of ±5%.

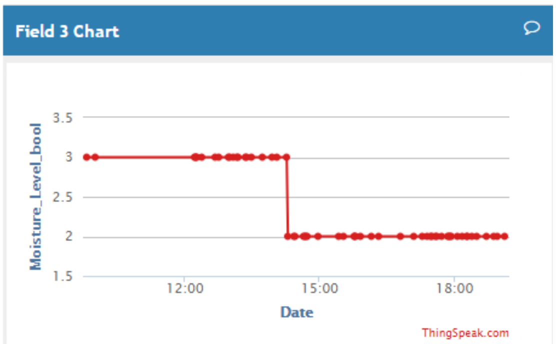

Figure 13. Soil Moisture Variations

The soil moisture readings are shown in Fig. 5.3. in order to evaluate the system we deliberately added water content to the system. We have divided the moisture levels into four divisions as shown in Table 5.1. Voltage is induced between the two pads of the moisture sensor depending upon the moisture content. Correspondingly, a value is generated based on the induced in the sensor. The same is programmed accordingly.

Value	Moisture Level
0	Very Low
1	Low
2	Average
3	High
4	Very High

Table 2. Moisture Level Programming

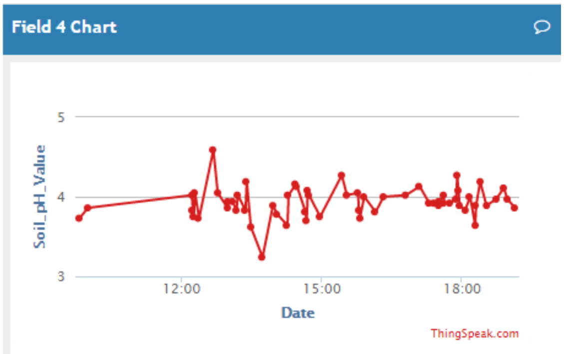

Figure 14. Soil pH variations

Fig 5.4 shows the variation of soil pH. We deliberately changed the composition of the soil by adding to it a known pH value solution to test its functionality. Experiments proved to be confined to the original results.

1) ***Correcting acid soil*:** If your soil is too acid, you must add alkaline material, a process commonly called liming. The most common liming material is ground limestone. The amount of lime you must add to correct pH depends not only on your soil type but also on its initial pH.
2) ***Correcting alkaline soil*:** If your soil is too alkaline, add a source of acidity. The most common material to add is powdered elemental sulfur. As a rule of thumb, add 1 pound of sulfur per 100 square feet to lower pH 1 point. But as with lime, the correct amount will depend on your soil type and its initial pH. Testing your soil and following lab recommendations is the best

approach if you want to lower the pH of an entire bed or area of your yard.

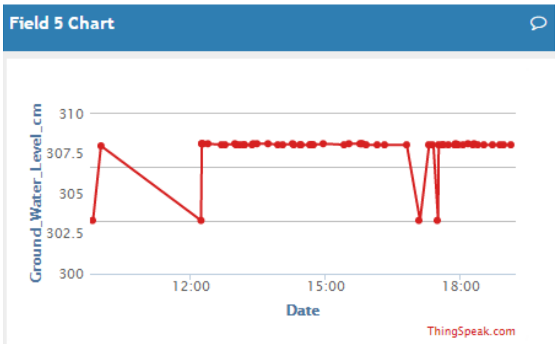

Figure 15. Ground Water Level in cm

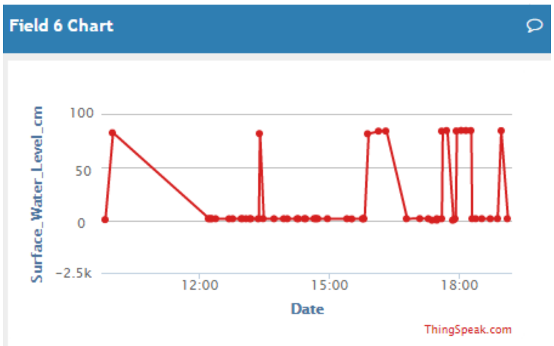

Figure 16. Surface Water Level in cm

Fig15. Indicates Ground Water level and Fig 5. 6 indicate Surface Water Level. The surface water level and moisture levels can be used to automate the irrigation for the fields.

The prototype devised for the above models is working satisfactorily and can be a handy tool for farmers in near future.

VI. CONCLUSION

In this project, we propose a smart Agriculture System that uses an Internet of Things architecture. This system can analyze an environment and intervene to maintain its adequacy.The system has an easy-to-upgrade bank of inference rules to control the agricultural environment. It mainly looks at inputs, such as, temperature, humidity, and pH.A solution for monitoring agricultural environments was presented. A prototype system is developed, demonstrating its functionality for retrieving data from sensors, relaying these data through a gateway and storing and analyzing the data on a server. Subsequently, the results are presented to users via a web interface. The system features a custom sensor design for power efficiency, data encryption for security, cost effectiveness using off-the shelf, cheap components, as well as scalability end ease of use.It uses the common IEEE 802.11 standard protocol stack for communication between device and the internet. Data transmitted to the cloud can be used to control the irrigation. The system can be further extended to alert the farmer to take necessary steps according to the weather parameters. As an engineer it is our responsibility to utilize the technological availabilities and mold them in such a way that they are useful to the public and farmers and help them grow and there by building a smarter country.

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