IOT BASED SMART AGRICULTURE

Project report submitted in partial fulfillment of the requirement for the degree of Bachelor of Technology

In

Computer Science and Engineering

By

Rudar Daman Singla (141225)

Udyan Sharma (141245)

Under the supervision of

Dr. Amit Kumar Singh

to

Department of Computer Science & Engineering and Information Technology

Jaypee University of Information Technology Waknaghat, Solan-173234,

Himachal Pradesh

Candidate's Declaration

I hereby declare that the work presented in this report entitled **IOT BASED SMART AGRICULTURE** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science and Engineering** submitted in the department of Computer Science & Engineering and Information Technology, Jaypee University of Information Technology, Waknaghat is an authentic record of my own work carried out over a period from August 2017 to May 2018 under the supervision of **Dr. Amit Kumar Singh**, Assistant Professor (Senior Grade), Computer Science & Engineering and Information Technology.

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

Rudar Daman Singla, 141225

Udyan Sharma, 141245

This is to certify that the above statement made by the candidate is true to the best of my knowledge.

Dr. Amit Kumar Singh
Assistant Professor (Senior Grade)
Computer Science & Engineering and Information Technology
Dated:

ACKNOWLEDGEMENT

We have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. We would like to extend our sincere thanks to all of them.

We are highly indebted to **Dr. Amit Kumar Singh** for their guidance and constant supervision as well as for providing necessary information regarding the project and also for their support in completing the project.

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ABSTRACT

Agriculture plays a vital role in the development of agricultural country. In India about 70% of population depends upon farming and one third of the nation's capital comes from farming. Issues concerning agriculture have always been hindering the development of the country. The only solution to this problem is smart agriculture, by modernizing the current traditional methods of agriculture. Hence the project aims at making agriculture smart using automation and IOT technologies. The highlighting features of this project include better practice of pesticides used in farms and preventing soil erosion hence resulting in greater yields. Secondly it includes smart irrigation with smart control and intelligent decision making based on accurate real time field data. Thirdly, maintain quality of soil by checking various properties of soil as temperature, humidity and nutrients. Fourthly, by preventing crop from getting destructed by stray animals from invasion detection technique using PIR Sensors. These operations will be controlled through any remote smart device or computer connected to Internet and the operations will be performed by interfacing sensors, Arduino, power supply and Raspberry pi.

Chapter-1

IOT Based Smart Agriculture: An Introduction

1.1 Introduction

Internet of Things (IoT) is the network of devices such as electrical appliances, physical devices and other things embed with sensors and actuators that enable the objects to establish a connection with different systems which in turn helps to exchange data. Everything is solely identified through its different embedded computing but it is operated in the existing infrastructure of Internet.

IoT sensed the objects and remotely controlled by accessing across existing infrastructure of network, creating more opportunities for various integration of the real world into the computer-based smart systems, and results in improved accuracy, economic benefits and efficiency to reduced human involvements. When augmentation is done with the actuators and sensors, it surrounds automation in various fields such as smart power plants, intelligent transportation, smart homes, smart grids and smart cities.

Applications:

For internet connected devices applications are extensive. There are a lot of categorizations has been suggested, most of which are

1. Infrastructure Management: Agriculture, Environmental Monitoring, Manufacturing, Energy Management, Building and home automation, Metropolitan Scale Deployments
2. Enterprise: Media
3. Consumer Application: Smart Home
4. Other fields: Transportation, Healthcare, Medical

   Every field finds application on IoT because of ability to network embedded devices with limited resources. All such systems collect data and information from natural ecosystem in sensing range and find applications in the fields of urban planning and environmental sensing.

Figure 1.1 Representation of Internet of Things

Agriculture:

Agriculture is an activity which mainly involves cultivation of plant and animal products which help in sustaining human life. Agriculture dates back to thousands of years, and since then it has been developed to a great extent by various cultures, climates and techniques. Hence, agriculture has changed a lot.

Agriculture employees the highest number of people throughout, about one third of the working population is engaged in agriculture and/or related activities, the service sector follows. However, the percentage of people involved in agricultural has been decreasing over the past centuries.

Figure 1.2 A Farm

Future of Indian Agriculture:

The future of Indian agriculture has to be built with knowledge and high end technologies which will definitely increase yields and also bring back the lost interest of people in agriculture. From independence the share of GDP (Gross Domestic Product) has decreased from half to one fifth. However, agriculture still greatly contributes to the earnings via exports and supply of raw materials to multiple industries. To meet the demand of food supplies of increasing population which is expected to reach around 1.6 billion by 2050, technological refinement and advancement in agriculture is very critical. [1]

Advancement in fields like biotechnology is paving the way for better crop quality and yields. In the advances India has made in agriculture during the last 25 years, the role of agricultural input industry has been really significant. The public R&D and seed supply has done a significant contribution to the consumable and non consumable crops production. The Indian government has been working with some agri-business companies to meet up the demands and needs of farmers from sowing to harvesting. [1]

Agriculture is the Primary sector of Economy. It makes direct use of natural resources. Most of the industries also depend on agriculture sector for their raw materials. The planned approach to development has helped the country to reach a stage where the country is self sufficient in food grains and has a comfortable buffer stock. These achievements have been possible mainly through the favorable policy framework. The policy of Indian Agriculture was to achieve food security by providing incentive for growth along with equitable access to food. As a result terrible famines have become events of the past and the agricultural production does not show large variation even in the event of adverse climatic condition. [2]

Table 1.1 GDP Contribution Chart [2]

Industry	2010-11	2011-12	Growth	Weightage	
Agriculture, forestry & Fishing	709103	728667	2.76%	14.01%	14%
Mining and Quarrying	109421	108469	-0.87%	2.08%	19%
Manufacturing	774162	793468	2.49%	15.25%	
Electricity, Gas and Water Supply	90944	98105	7.87%	1.89%	
Construction	384199	404617	5.31%	7.78%	67%
Trade, Hotels, Transport & Communication	1330455	1462772	9.95%	28.12%	
Financial, Insurance, Real Estate & Business	849995	931714	9.61%	17.91%	
Community, Social & Personal Services	637675	674703	5.81%	12.97%	
Total	4885954	5202515	6.48%	100.00%	100.00%

Due to some of the reforms introduced in the early 90s the overall trade flow in India increased significantly. India is the EU's tenth largest trading partner accounting for 1.8% of the total which is accounted for about €2 billion in 2005. Whereas the agricultural and food products have a smaller share in the overall Indian trade and their exports account for only 9% of the total exports and 5% of the total imports. [2]

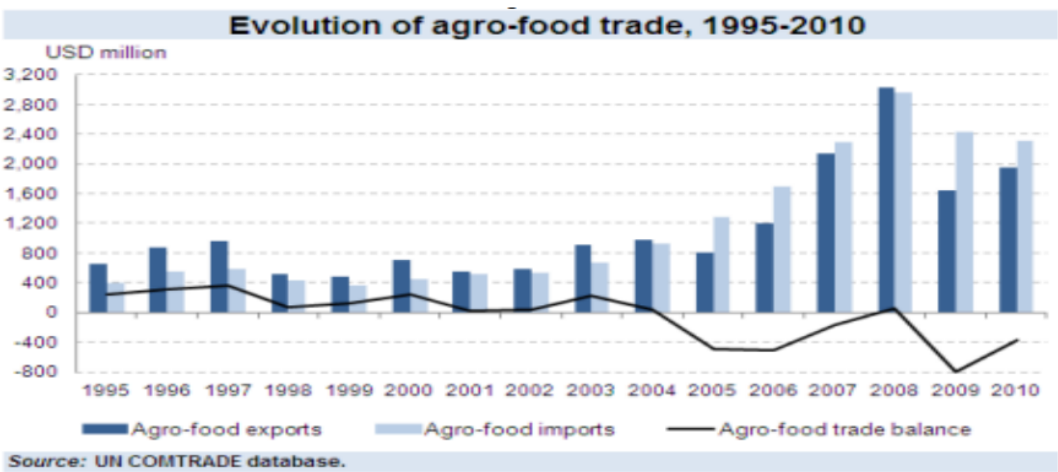

Figure 1.3 Evolution of agro-food trade [2]

The Green revolution was a major change in agriculture and related fields. Further research and development has helped us achieve in lower food prices, a better nutrition report, enhanced agricultural exports and international ties in terms of trade. [1]

Royal Agricultural Society of England, founded during 1790s in UK, paved the way for growth of experimental farming. Similarly, in US, the US Department of Agriculture was established. These organizations helped in revolutionizing the techniques which were used in farming. [1]

India underwent a similar massive revolution with the establishment of Department of Agriculture in each Indian province in 1880 which was the time when British rule was prevalent in the country. When the country got independence, again the primary concern of the leaders of those times was research and development in agriculture as it was one of the primary employer of the nation during those times a committee was established which made heavy changes in management, of the research work in the country. [1] All the research centres were know under one central name, Indian Council of Agricultural Research (ICAR) and at the state level the research and education transferred to State Agricultural Universities (SAUs). All these efforts helped in the development of the agriculture sector and helped it to become as a key sector in strengthening both the employment ratio of the company as well as the economy of the country. [1]

1.2 Problem Statement

The problem statement represents the need for the proposed system which is; the Indian agriculture is on a setback due to lack of proper knowledge of best agricultural practices, which when implemented can increase the yields at minimal costs instead the people are scaring away from agriculture and related activities due to heavy loans which they have incurred or have to incur on themselves in order to get better yields or at least get a living out of agriculture, scarcity of natural resources is also an add on for farmers quitting up on farming and hence the Indian economy is also getting affected by great deal as a large proportion of fertile lands of our country are getting wasted, which were otherwise the major source of the nation's GDP once.

So through this system we want to present a very trivial solution to this problem by introducing an automated farming scheme which can help the farmers do farming in an efficient manner with even scarce resources and higher yield which is more secure and grown with a more careful and a well devised plan.

1.3 Objectives

The objective of the proposed system is to increase the standard of agricultural economy in India. Agriculture plays an important role in the development of an agriculture based country like India. In India around 70% of population depends solely upon farming and related activities and one third of the nation's capital comes from it. Issues concerning agriculture have always hindered the growth of the nation in some way or the other. One way out to this problem is smart agriculture, i.e. by mixing the current traditional agricultural techniques with a touch of modern agriculture. Hence the project aims at making agriculture easy and hassle free using smart automation techniques using IOT technologies as the basis of it. The highlighting features of this project include better practice of pesticides used in farms and preventing soil erosion hence resulting in greater yields. Secondly, it includes a smart and automatic irrigation with smart control and intelligent decision making based on accurate real time field data. Thirdly, maintain quality of soil by checking various properties of soil as temperature, humidity and nutrient content. Fourthly, by preventing crop from getting destructed by stray animals from invasion detection technique using PIR (Passive Infrared) Sensors implanted on adequate distances across the entire perimeter of the farm. These operations will be controlled through a remote smart device or computer connected to Internet and the operations will be performed by interfacing sensors, Arduino, electrical appliances, power supply and Raspberry pi.

Figure 1.4 A Smart IoT Based Farm

1.4 Methodology

The methodology adopted in the proposed system is that it consists of multiple Arduino boards as per the requirements and a centralized computer, the raspberry pi. The pi is further connected to one centralized server which acts as a junction of information interchange between pi and the user (the farmer). Various notifications regarding low moisture, fertilizer needed and invasion will be provided to the user through an app platform. The App has 2 main modes of operation, one in which the user will decide when to turn off or on the electrical appliances depending on the conditions of the farm as reported by the app from the statistics coming from the farm via the sensors. The second method which we call the auto pilot mode wherein the user just selects the crop which he has harvested at the moment and the app takes decision whether to turn on/off the water supplies. This mode is a great boon for farmers and they can now take out some time for their social lives and still have greater and better yields.

The Arduino is connected to various sensors which send their readings for processing to the Arduino. The sensors included in this system are: soil moisture sensor, electrochemical sensor, PIR Motion Sensor, pH sensor and temperature-humidity sensor.

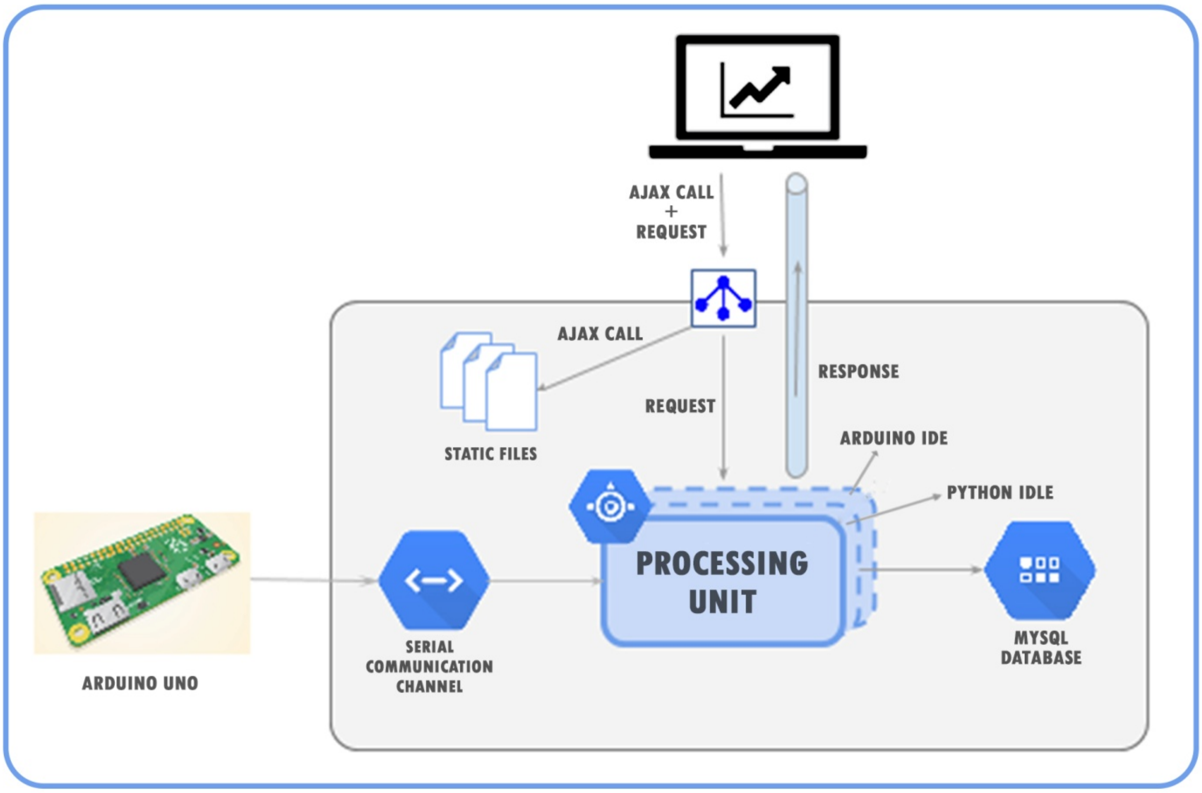

Figure 1.5 Methodology in proposed system

Chapter-2

LITERATURE SURVEY

1. IOT Based Smart Agriculture Monitoring System

Summary: In this paper, author included various features like temperature & moisture sensing, intruders scaring, security, GPS based remote monitoring to any GSM network operator, the wetness of leaf and irrigation facilities in proper way. Various factors of soil properties and environmental factors for soil are noted down continuously by using the wireless sensor networks. (Dr.N.Suma et al. [6], 2017)

Advantages:

- The main feature of this paper is a GPS based remote controlled robot which perform tasks like weeding, spraying, moisture sensing, human detection and keeping vigilance.
- Sending notification regarding any alert to any GSM network operator using GSM Module.
- The technique of wireless sensor network proposes efficient and low cost monitoring of temperature and soil moisture from remote location from different locations of the farm.

Disadvantages:

- Microcontroller (PIC16F877A) used in this system is not properly able to share data to cloud and manage it properly.
- PIR Sensor is of no use in such a system which results in cost cutting because it detects the infrared radiation emitted or reflected from an object.

2. IOT Based Smart Agriculture Research Opportunities And Challenges

Summary: In this paper, authors developed the system using universal asynchronous receiver transmitter (UART) interface. Also microcontroller and sensors are used with UART such that transmission of the data was done by taking hourly samples and buffering the data, transmitting it and after transmission verify the status messages. This system is designed for Accurate fertilization, Monitoring quality of water, Monitor soil constituents, soil humidity, light, wind, air, and automatic improvement of quality of water etc. (Aditi Mehta, Sanjay Patel [7], 2016)

Advantages:

- The user can override the system by switching from auto mode to the manual mode.
- The network includes NFC, 3G, LTE, Bluetooth, GSM, RFID, ZigBee, WLAN, WPAN, Wi Max and various other wireless communication protocol technologies.
- Acute fertilization is there which checks the use of fertilizers used for crops.

Disadvantages:

- The major drawback of the system is the cost.
- Attenuation of radio frequency (RF) signals also generated when sensor deploys under the soil.

3. **IOT BASED SMART AGRICULTURE**

Summary: Most of the papers just emphasizes on the use of wireless sensor network via which data is collected from different types of sensors and then send it to main server using wireless protocol which in turns helps to monitor the system. This paper instead comes up with the idea that monitoring of environmental factors is just not enough and a complete solution to improve the yield of the crops. This paper therefore proposes a system which suggests both monitoring the field data as well as controlling the field operations using IoT based technologies. (Nikesh Gondchawar et al. [8], 2016)

Advantages:

- This paper provides us a solution to completely automate farms instead of just providing us insights on the farm data.
- Smart robot remote controlled based on GPS to perform various tasks like moisture sensing, spraying, keeping surveillance, animals and birds scaring etc.
- Smart system for irrigation with smart control of irrigation and also intelligent decision making based on the real time data from different locations of fields.
- Also smart warehouse management system which includes theft awareness in the warehouse, humidity and temperature maintenance.

Disadvantages:

- In this paper a predefined algorithm for automatic irrigation after a threshold limit is met is embedded in the microcontroller-based gateway which is irrespective of the crop which we are sowing and hence this would require change in the threshold limit for each and every crop.
- The drawback of the system was introduction of heavy cost which was introduced due to the automated robot which was sufficient enough to handle the entire farming activities without any human involvement.

4. **IOT BASED SMART FARMING SYSTEM**

Summary: Smart Farming System is proposed in this paper which will use concept of IoT, WSN and cloud computing to help farmer plan an irrigation schedule for his farm. Proper scheduling of irrigation and fertilization is very important for proper development of crops. (Akshay Atole et al. [9], 2017)

Advantages:

- This paper fetches data from the field and after analysis provides an irrigation schedule to the farmer.

Disadvantages:

- A lot of research work and data gathering needs to be done to know the past weather conditions of the particular area and hence each time the system needs to be reprogrammed for every farmer that lives in distant areas.
- The drawback of the system is that no action is performed automatically only data collection and analysis is done.

5. INTERNET OF THINGS BASED EXPERT SYSTEM FOR SMART AGRICULTURE

Summary: Smart Farming System is proposed in this paper which will use concept of IOT, WSN and cloud computing to help farmer plan a irrigation schedule for his farm. Proper scheduling of irrigation and fertilization is very important for proper development of crops. (Raheela Shahzadi et al. [10], 2016)

Advantages:

- This paper fetches data from the field and after analysis provides an irrigation schedule to the farmer.

Disadvantages:

- A lot of research work and data gathering needs to be done to know the past weather conditions of the particular area and hence each time the system needs to be reprogrammed for every farmer that lives in distant areas.

6. INTERNET OF THINGS BASED APPROACH TO AGRICULTURE MONITORING

Summary: The system was developed using TelosB, RFID, Wi-Fi Gateway & sensors and all the system is designed by making a control center and provide information to server using web services. This system is designed to for Soil properties - electrical conductivity, temperature, moisture and Soil nutrients - Nitrogen (N), Phosphorous (P), Potassium (K), and Spectral reflectance for plant nutrients**. (**A. Paventhan [11], 2016)

Advantages:

- Soil nutrients and properties are properly notified on web application.
- Support for remote field deployments & monitoring.
- Proper command and control center is there to check all parameter properly.

Disadvantages:

- Complex system not a good option for farmers.
- The drawbacks of the system were its high cost technology used.

7. **SOIL NUTRIENT IDENTIFICATION USING ARDUINO**

Summary: In this paper, main focus is on soil nutrients. As the measurement of soil nutrients is greatly required for plant growth to be proper and effective fertilization. The important soil nutrients required for the plant growth are Nitrogen, Phosphorus and Potassium. These nutrients can be monitored by using electrochemical sensor. **(**R.Sindhuja et al. [21], 2017)

Advantages:

- Rapid detection of soil nutrients.
- Proper fertilization and irrigation for proper plant growth.

Disadvantages:

- The standard testing time for NPK is more due to complex soil pretreatment and chemical analysis.

8. **PASSIVE INFRARED (PIR) SENSOR BASED SECURITY SYSTEM**

Summary: In this paper, security system based on PIR sensor is designed which turned on the webcam when there is an intruder in detection range of PIR Motion Sensor. The system capture the live video using webcam which saves power when lighting system can be reduced at night. **(**Pema Chodon et al. [22], 2013)

Advantages:

- Reduction of power consumed by lighting system at night.
- Saves memory of the recording system as recording starts only when the webcam is on.

Disadvantages:

- System is not compatible for the intruder entering from another side.

9. **LOW COST SOLUTION FOR TEMPERATURE AND HUMIDITY MONITORING AND CONTROL SYSTEM USING TOUCH SCREEN TECHNOLOGY**

Summary: In this paper, the system for temperature and humidity control monitor using Touch screen and LCD display is made. The control is built using AVR ATmega16 Microcontroller and DHT11 is used to sense the humidity and temperature. **(**Ashish Sharma et al. [23], 2013)

Advantages:

- More stability and linearity with all the sensors.
- Low cost solution for temperature and humidity monitor using touch screen technology.

Disadvantages:

- Remote access for the humidity and temperature monitoring is not there in the system.

10. SMART IRRIGATION CONTROL SYSTEM

Summary: In this paper, the system for smart irrigation is developed using soil moisture sensor and the water level should check by using water level sensor. The schedules for irrigation can be fixed and also remotely controlled by using GSM module. **(**Deepak Kumar Roy et al. [24], 2013)

Advantages:

- Water wastage reduced using smart irrigation control technology.
- The control for smart irrigation is remotely without physical presence in field.

Disadvantages:

- PLC design for smart irrigation system is very complex.

Table 2.1 Various Technologies used

Year Published	Title	Author (s)	Technology Used
2013	"Passive Infrared (PIR) Sensor Based Security System"	Pema Chodon et al.[22]	PIR Sensor, Webcam
2013	"Internet Of Things Based Approach To Agriculture Monitoring"	A. Paventhan [11]	TelosB, IRIS, AVR Raven, Sensors, Router, RFID
2014	"Smart Irrigation Control System"	Deepak Kumar Roy [24]	Water Level Sensor, GSM Controller and Soil Moisture Sensor
2016	"Low cost Solution for Temperature and Humidity monitoring and control System using Touch Screen Technology"	Ashish Sharma et al.[23]	DHT11, Touch Screen, AVR ATmega16 Microcontroller
2016	"IOT Based Smart Agriculture"	Nikesh Gondchawar et al.[8]	Camera and actuators with micro-controller and raspberry-pi, ZigBee or Wi-fi modules
2016	"IOT Based Smart Agriculture Research Opportunities And Challenges"	Aditi Mehta et al.[7]	RFID, ZigBee Modules, Raspberry Pi, Sensors
2016	"Internet Of Things Based Expert System For Smart Agriculture"	Raheela Shahzadi et al.[10]	IOT and Cloud computing
2017	"IOT Based Smart Agriculture Monitoring"	N. Suma et al.[6]	PIC16F877A-MICROCONTROLLER, GSM Module, Sensors
2017	"IOT Based Smart Farming System"	Akshay Atole et al.[9]	Cloud computing and Wireless Sensor network
2017	"Soil Nutrient Identification Using Arduino"	R.Sindhuja et al.[21]	Electrochemical Sensor and Arduino Microcontroller

Chapter-3

SYSTEM DEVELOPMENT

3.1 Circuit Design

Breadboard:

A breadboard is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connect the holes on the top of the board. The metal strips are laid out as shown below. Note that the top and bottom rows of holes are connected horizontally and split in the middle while the remaining holes are connected vertically.

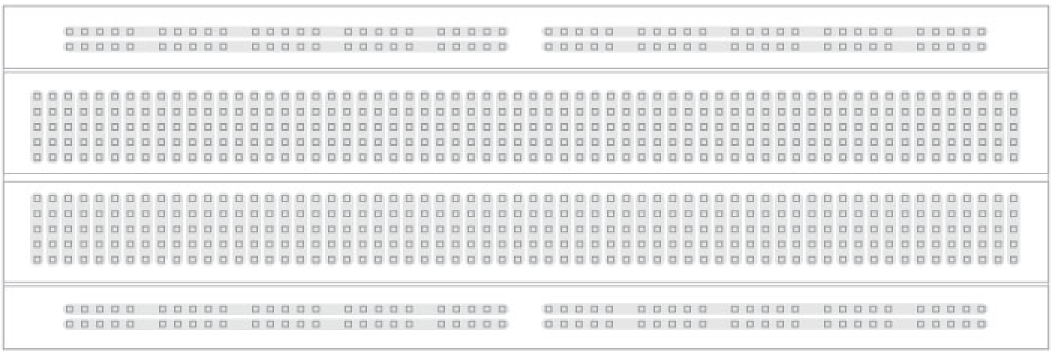

Figure 3.1 Breadboard Wiring

Soil Moisture Sensor:

It contains 3 pins: one is for ground, second one is Vcc for voltage input and the third one is for analog input. Ground pin and Voltage pin is connected to the respective ground and Vcc pin in Arduino Uno. The sensor measures moisture level in (volume %). The input value from the sensor is analog and is connected to the A0 input pin on Arduino Uno.. The analog input from the sensor is required to map between 0-100 because moisture reading is measured in percentage.

Humidity & Temperature Sensor (DHT11):

DHT11 contains 3 pins: one is for ground, second one is Vcc for voltage input and the third one is for analog input. Ground pin and Voltage pin is connected to the respective ground and Vcc pin in Arduino Uno. It has two basic units one for measuring humidity and the other for sensing temperature which is basically a thermistor. There is an additional IC which helps in getting the readings ready for the microcontroller. The humidity is measured by calculating the conductivity of a liquid substrate which changes on change in humidity. The temperature is measured using a thermistor. Both temperature and humidity measures using analog input by connecting the input pin of the sensor with A1 pin on Arduino Uno.

Digital Buzzer Module:

It is just a simple sound making module on High/Low to make it sound. On just changing the frequency for the buzzer the buzz sound creates. It contains 3 pins: one is for ground, second one is Vcc for voltage input and the third one is for digital input. Ground pin and Voltage pin is connected to the respective ground and Vcc pin in Arduino Uno. The sensor is connected to pin 3 at digital input side on Arduino Uno. The buzzer sound can produce by just writing HIGH/ LOW to the sensor. In this project, HIGH/LOW sound starts generating when obstacle enters the detecting range of PIR sensor and stops at exit of that obstacle and creates invasion alert for that obstacle.

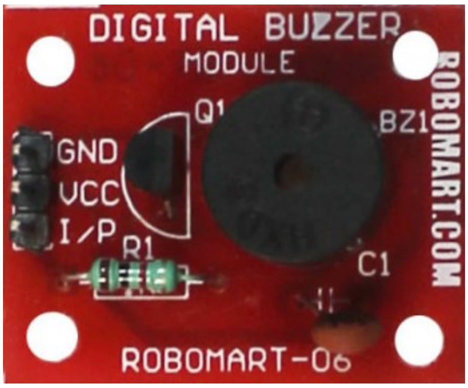

Figure 3.2 Digital Buzzer Module

PIR Sensor:

The PIR is used for motion detection which is much better than the IR sensor as IR sensor senses the Infrared radiation by emitting an IR radiation and waiting for it to be re-bounced by some obstacle and hence it is able to recognize a motion.

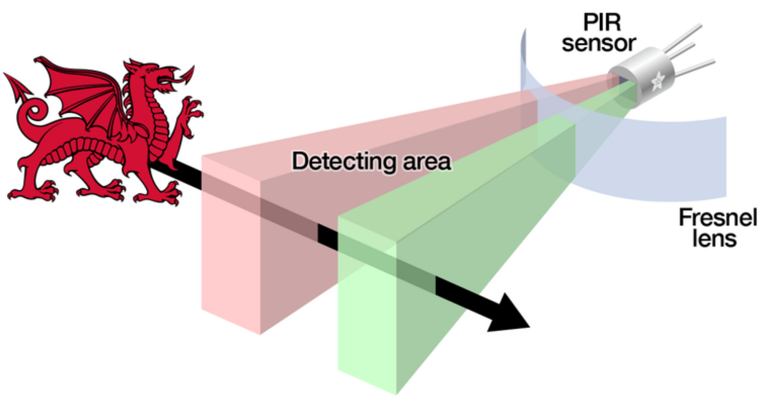

Figure 3.3 PIR sensor detection area

It contains 3 pins: one is for ground, second one is Vcc for voltage input and the third one is for analog input. Ground pin and Voltage pin is connected to the respective ground and Vcc pin in Arduino Uno. The input for this sensor is digital input. The sensor is connected to pin 8 at digital input side on Arduino Uno. This sensor does not radiate IR beams of its own instead they detect IR beams radiated from warm bodies and has two detectors if there is a blockage of IR on the first one and also on the second one only then the PIR sensor detects a motion.

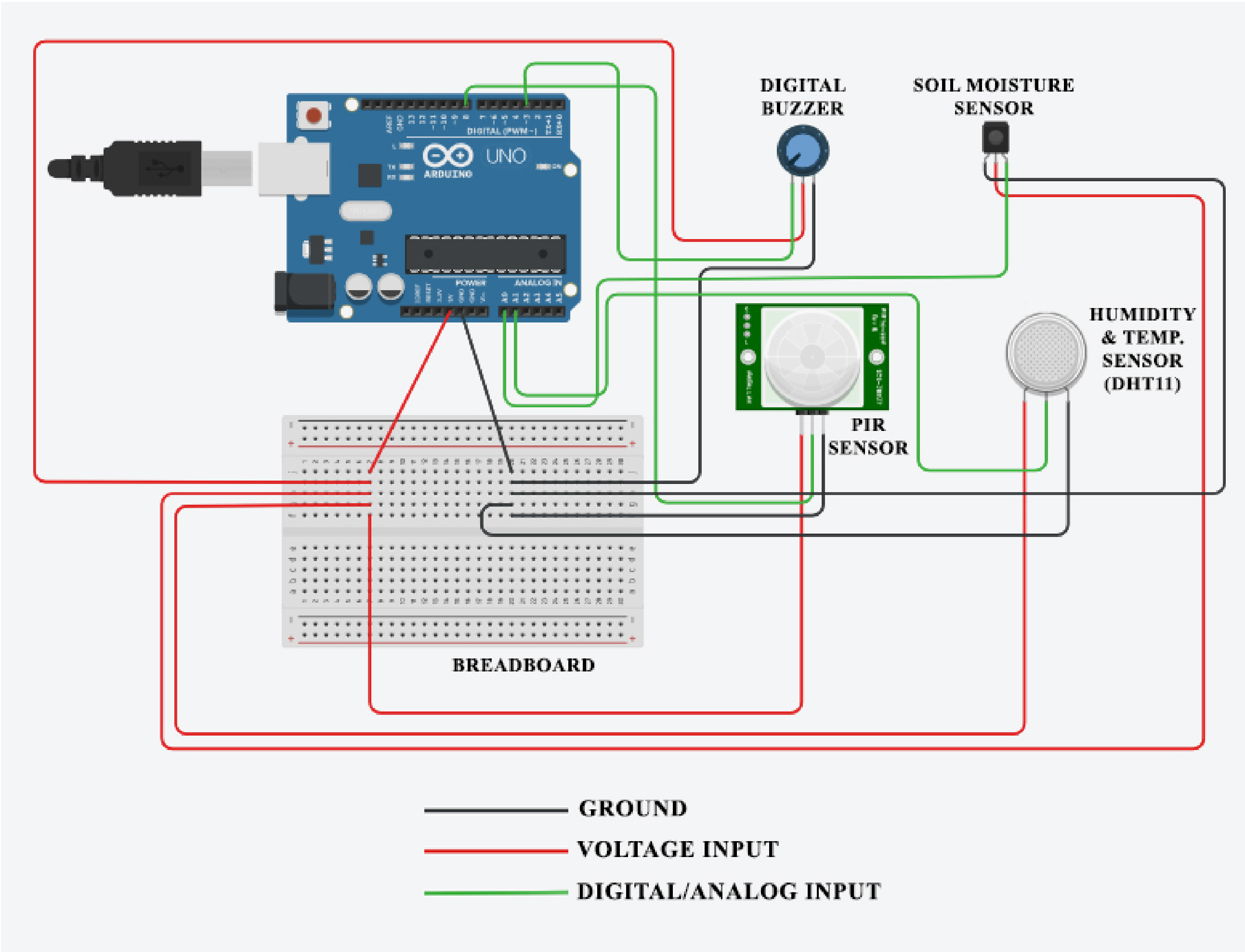

Figure 3.4 Circuit Design

3.2 Algorithm

```
//Arduino Pseudo Code
//Read Sensors Data
//1. Soil Moisture Sensor
Moisture = analogRead (sensor_pin)
//2. Temperature-Humidity Sensor (DHT11)
DHT.read11 (dht_apin)
Humidity = DHT.humidity
Temp = DHT.temperature
//3. PIR Sensor
PIR = digitalRead (inputPin);

//Python Pseudo Code
Import serial // Python Library for serial communication
Import MySQLdb // Python Library for Database Connection
Import time // Python Library for time functions
db = MySQLdb.connect ("127.0.0.1","root","","farming" ) //Connection with Database
ser = serial.Serial ('COM3', 9600) // Serial connection with Arduino
repeat
data = ser.readline() //Read Arduino Output
ts = int(time.time()) // Current Time Stamp
if countTime + delayTime = CurrentTimeStamp then
    read all sensor data and input to DB
else
    read invasion data
until ~kill
```

3.3 Analytical

Our proposed system consists of an Arduino board and the centralized computer, the raspberry pi. The pi is further connected to one centralized server which acts as an junction of information interchange between pi and the user (the farmer). Various notifications regarding low moisture, fertilizer needed and invasion will be provided to the user through this app platform. The App has 2 main modes of operation, one in which the user will decide when to turn off or on the electrical appliances depending on the conditions of the farm as reported by the app from the statistics from the farm via the sensors. The second method which we call the auto pilot mode wherein the user just selects the crop which he has harvested right now and the app takes decision whether to turn on/off the water supplies. This mode is a great boon for farmers and they can now take out some time for their social lives.

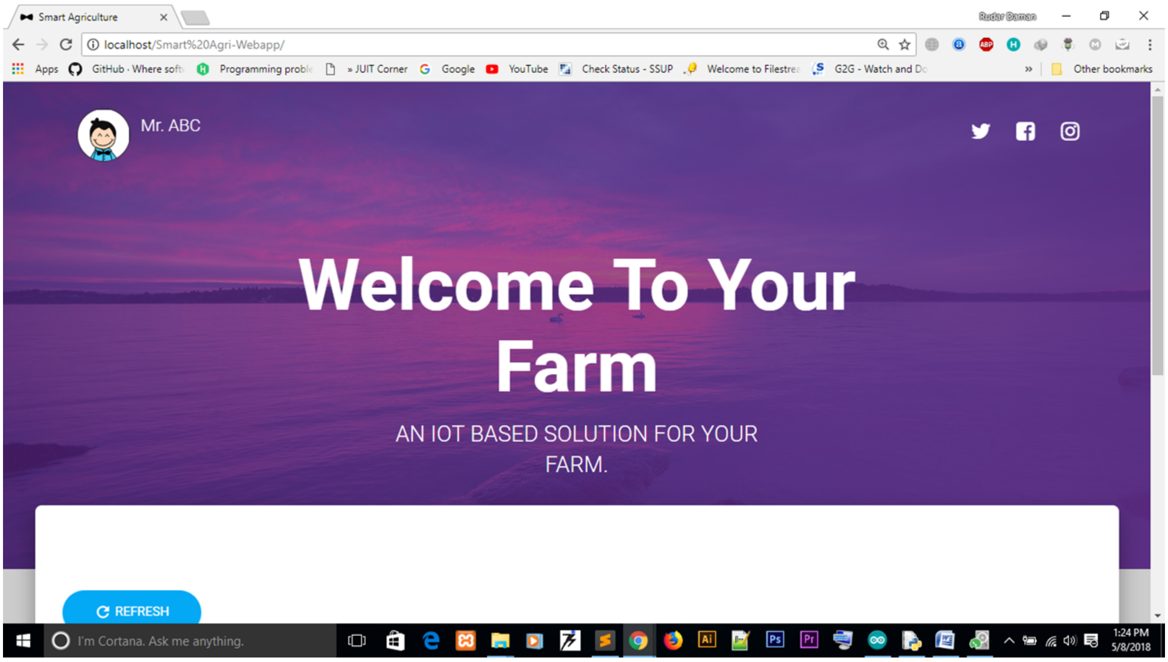

Figure 3.5 A Snapshot of Web App

The Arduino is connected to various sensors which send their readings for processing to the Arduino. The various sensors this system has our: soil moisture sensor, electrochemical sensor, PIR Motion Sensor, pH sensor and temperature-humidity sensor.

HARDWARE TOOLS

- **Soil-Moisture Sensor**

  The soil moisture sensor measures moisture level in (volume%) which is determined by the help of the 2 probes which in turn measure dielectric permittivity, hence lower the content of water in the soil, higher the output and vice versa.

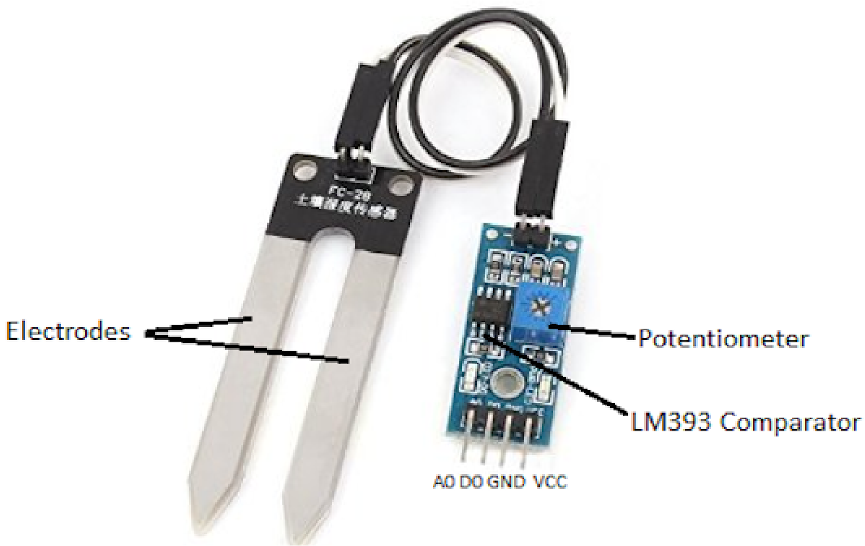

Figure 3.6 Soil-Moisture Sensor

- **Electro Chemical Sensor**

  An Electro Chemical Sensor use an ISE or ISFET transistor to measure voltage difference between electrode and the soil related to specific ions(H+,K+,NO3-) and hence helping the farmer to decide which fertilizer to add to the soil.

- **PIR Motion Sensor**

  The PIR is used for motion detection which is much better than the IR sensor as IR sensor senses the Infrared radiation by emitting an IR radiation and waiting for it to be re-bounced by some obstacle and hence it is able to recognize a motion. The PIR sensor does not radiate IR beams of its own instead they detect IR beams radiated from warm bodies and has two detectors if there is a blockage of IR on the first one and also on the second one only then the PIR sensor detects a motion.

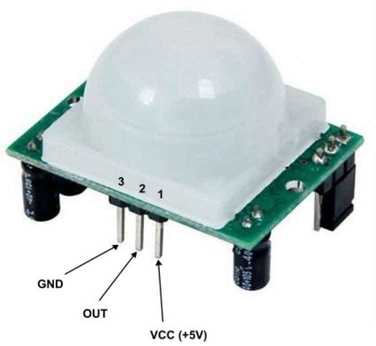

Figure 3.7 PIR Motion Sensor

- **pH Sensor**

  The pH sensor measures the difference in electric potential between the substance/sample and a reference electrode. This potential is related to the pH of the sample that can be controlled by providing nutrients to the soil by the way of adding specific fertilizers to the soil when required.

Figure 3.8 pH Sensor

- **Temperature-Humidity Sensor (DHT11)**

  It has two basic units one for measuring humidity and the other for sensing temperature which is basically a thermistor. There is an additional IC which helps in getting the readings ready for the microcontroller. The humidity is measured by calculating the conductivity of a liquid substrate which changes on change in humidity. The temperature is measured using a thermistor. Thermistor in DHT11 acts as a variable resistor which changes its resistance according to the temperature.

Figure 3.9 Temperature-Humidity Sensor (DHT11)

SOFTWARE TOOLS

- **Arduino IDE:** The Arduino Software is an IDE (Integrated Development Environment) which provides us with a text editor which helps us write the code to be uploaded to the arduino. The Arduino IDE is made using the java language and the codes written in it to program the Arduino board is Arduino language which is merely a set of C/C++ functions.

Figure 3.10 ARDUINO IDE

To code on Arduino IDE file is created which is called as sketch. The sketch is then loaded on the arduino board which then actually performs the required data collection and further processing tasks as per the code.

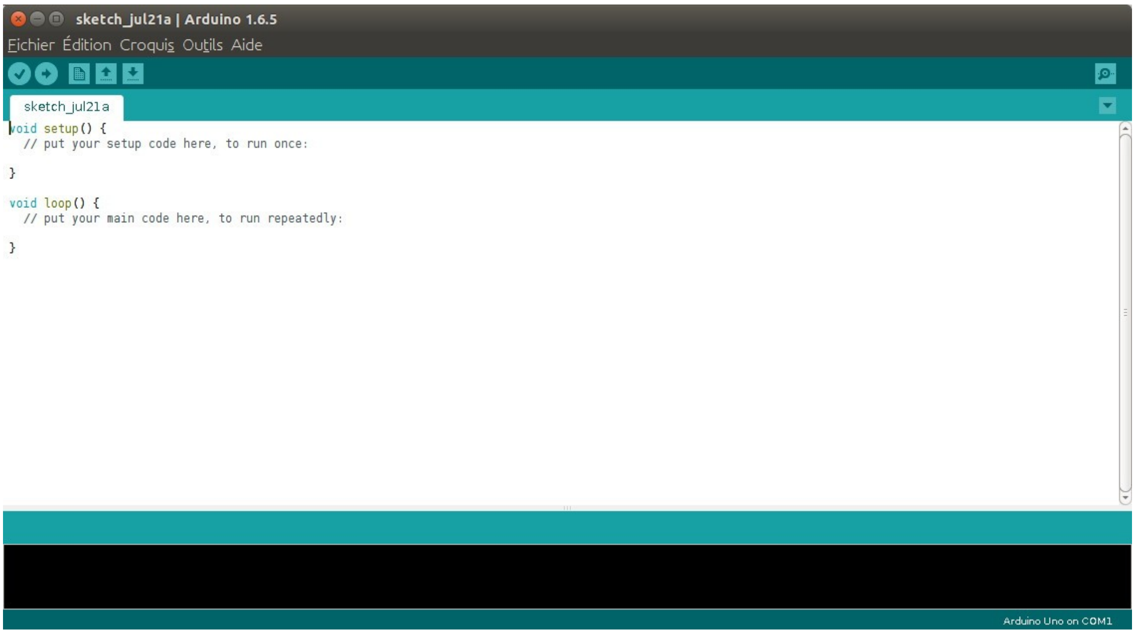

Figure 3.11 ARDUINO SKETCH

- **PySerial module:** This module allows access to serial port which in turn allows the communication via the same.

- **Python IDLE:** It is the IDE (Integrated Development Environment) for python language. The arduino sends the data using serial communication to the local PC and then we process that data using python by developing a python script which fetches all the data coming from the arduino using pySerial library.

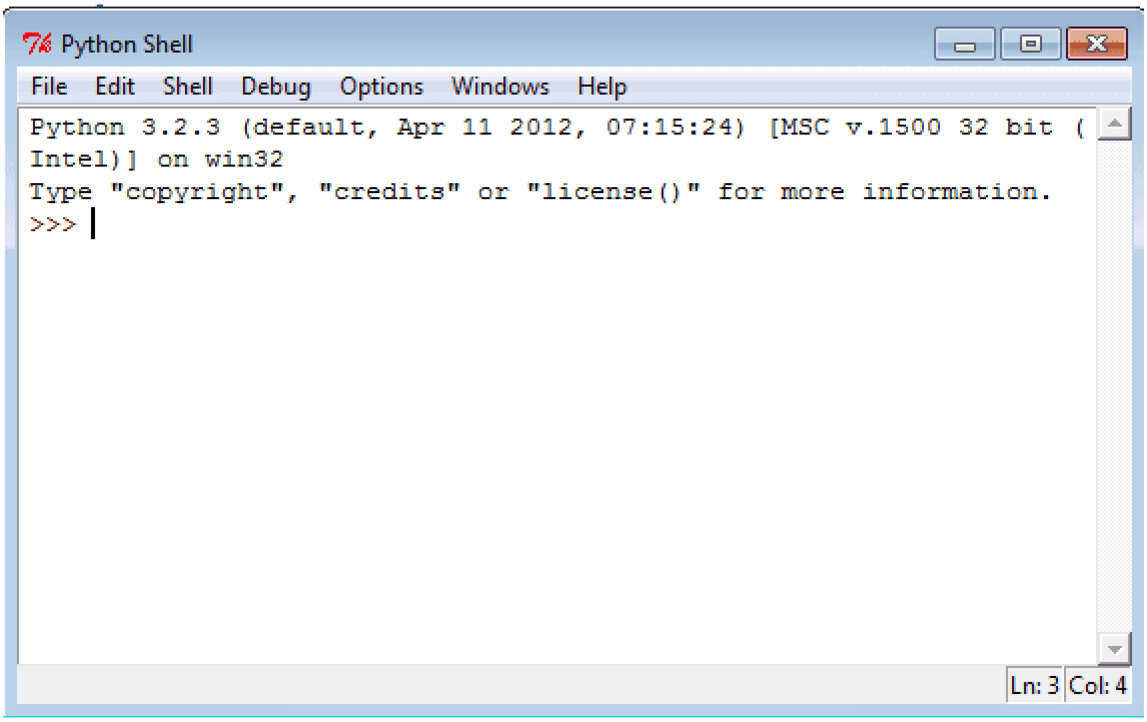

Figure 3.12 Python IDLE

- **MySQL:** It is one of the most famous and commonly used databases. A database is a store of data from where various applications can use it simultaneously. Herein we have stored the data coming from the arduino board to the MySQL database via the python script which we have written. The php code snippet then uses it to send the same data to the internet and carry it back to the database.

Figure 3.13 MySQL

- **PHP:** PHP is yet another language which we have used to create the backend of our web app. This also fetches the data from the MySQL database and stores the data coming back from the web app as the response from the received data back into the database which is later taken back to arduino using the python script.

Figure 3.14 PHP

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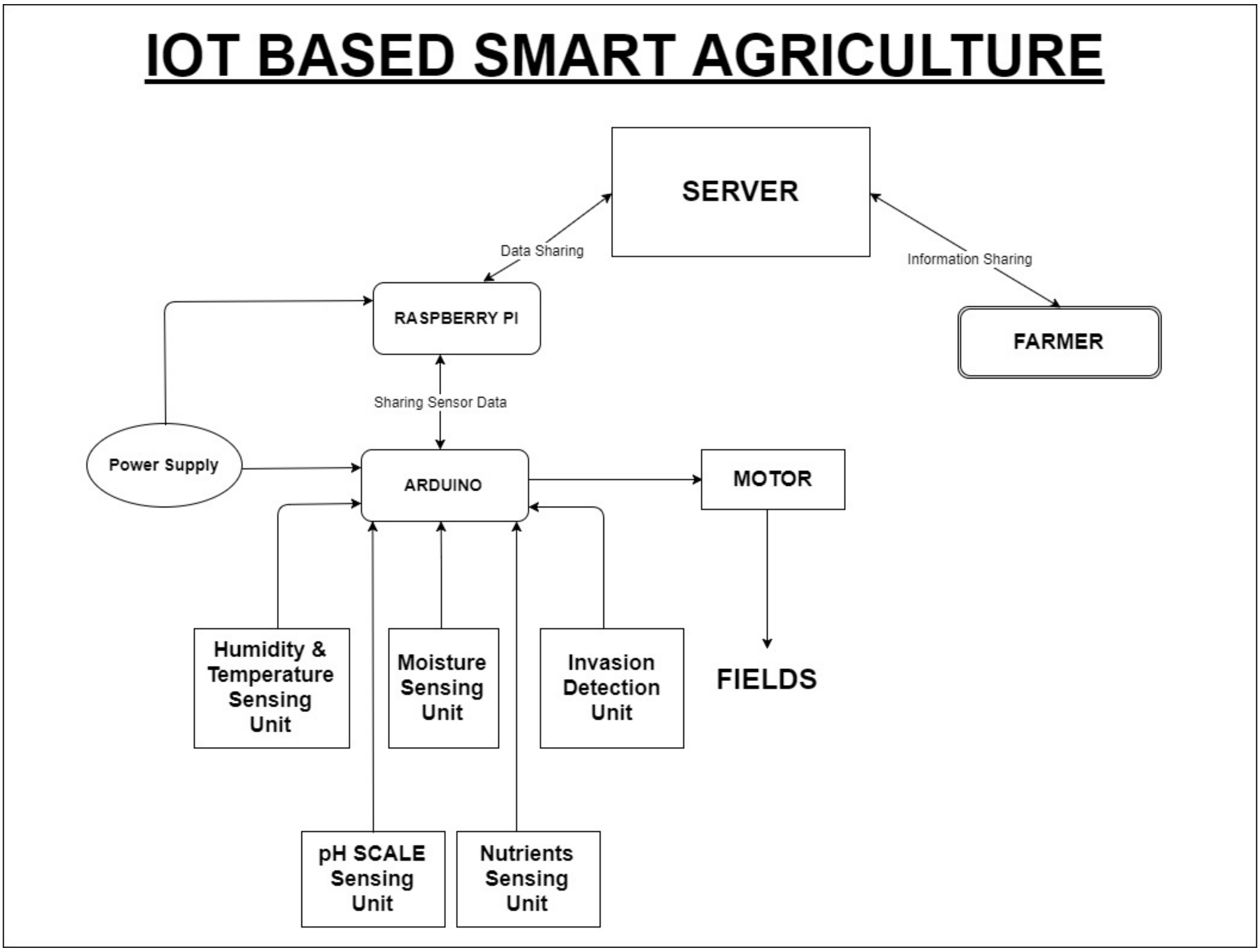

Figure 3.15 Detailed Data Flow Diagram

3.4 Computational

- **Soil Moisture Sensor**

  The input value from the sensor is analog and will store into a variable. The analog input from the sensor is required to map between 0-100 because moisture reading is measured in percentage. So, mapping for this can be done using the follow function:

  map(output_value,550,10,0,100).

  The reading for the sensor in dry soil is 550 and for wet soil it is 10. So, we mapped it from the range of 10-550 from 0-100 using map function.

- **DHT11**

  DHT11 sensor measures humidity from the resistance and transmits the readings directly to the variable in Arduino code. Also the temperature readings come from the thermistor (NTC temperature sensor) mounted at the surface built into the unit.

  <dht.h> is the library which takes input from the sensor by using read11 () function present in dht.h library.

  DHT.read11 (dht_apin)

  After read data from sensor temperature and humidity can access from input of sensor as:

  Humidity = DHT.humidity

  Temperature = DHT.temperature

3.5 Experimental

Table 3.1 Properties of Soil for the crop of Rice [3]

Property	Composition
Temperature (°C)	20 - 40
Moisture (vol %)	30 - 35
Relative Humidity (%)	50 - 70
pH Range	5.5 - 6.5

Table 3.2 Properties of Soil for the crop of Apple [25]

Property	Composition
Temperature (°C)	21 - 24
Moisture (vol %)	20 - 25
Relative Humidity (%)	10-20
pH Range	5.5 - 6.5

Table 3.3 Sample Data from Sensors [4]

		SMART	AGRICULTURE	SYSTEM		
DATE	TIME	SOIL MOISTURE	LIGHT INTEN.	HUMIDITY	TEMP.('C)	TEMP.('F)
25-10-15	16:31:01	346	32	31.21	27	80.6
25-10-15	16:31:03	347	34	31.21	17	62.6
25-10-15	16:31:04	344	33	31.21	28	82.4
25-10-15	16:31:06	388	33	31.21	34	93.2
25-10-15	16:31:07	651	32	31.21	21	69.8
25-10-15	16:31:09	651	33	31.21	30	86
25-10-15	16:31:10	651	33	31.21	27	80.6
25-10-15	16:31:12	550	31	31.21	17	62.6
25-10-15	16:31:13	418	33	31.21	17	62.6
25-10-15	16:31:15	309	33	31.21	25	77
25-10-15	16:31:16	328	32	31.21	32	89.6
25-10-15	16:31:18	344	32	31.21	26	78.8
25-10-15	16:31:19	354	35	31.21	31	87.8
25-10-15	16:31:21	357	33	31.21	28	82.4
25-10-15	16:31:22	341	33	31.21	31	87.8
25-10-15	16:31:24	352	34	31.21	36	96.8
25-10-15	16:31:25	347	32	31.21	21	69.8
25-10-15	16:31:27	352	34	31.21	17	62.6
25-10-15	16:31:28	343	33	31.21	22	71.6
25-10-15	16:31:30	351	34	31.21	35	95
25-10-15	16:31:31	347	34	31.21	31	87.8
25-10-15	16:31:33	342	32	31.21	29	84.2
25-10-15	16:31:34	339	34	31.21	31	87.8
25-10-15	16:31:36	343	32	31.21	25	77
25-10-15	16:31:37	339	31	31.21	36	96.8
25-10-15	16:31:39	345	34	31.21	22	71.6

Table 3.4 Output Data from Sensors

S. No.	Humidity	Moisture	Temperature	Time Stamp
1	0	28	28	5/7/2018 15:43
2	0	28	28	5/7/2018 15:44
3	0	28	28	5/7/2018 15:44
4	0	28	28	5/7/2018 15:44
5	0	28	28	5/7/2018 15:44
6	0	27	28	5/7/2018 15:44
7	0	27	28	5/7/2018 15:44
8	0	27	28	5/7/2018 15:45
9	0	27	28	5/7/2018 15:45
10	0	27	28	5/7/2018 15:45
11	0	27	28	5/7/2018 15:45
12	0	27	28	5/7/2018 15:45
13	0	26	28	5/7/2018 15:45
14	0	26	28	5/7/2018 15:46
15	0	27	28	5/7/2018 15:46
16	0	27	28	5/7/2018 15:46
17	0	27	28	5/7/2018 15:46
18	0	27	28	5/7/2018 15:46
19	0	27	28	5/7/2018 15:46
20	0	27	28	5/7/2018 15:47

Chapter-4

PERFORMANCE ANALYSIS

All the sensors have a standard set of performance as established by the respective manufacturers. As sensors will be implanted for a permanent use in the soil and will be giving readings on a very regular basis we will have to do a conformal coating which is basically a spray which has to be used on the sensors so that they do not get corroded or damaged.

Figure 4.1 Conformal Coating

Soil Moisture Sensor:

Table 4.1 Soil Moisture Sensor Performance Parameters [17]

Model Name	YL -38
Sensing Range	0 to 45% volumetric water content of soil
Operating Temperature	-40 °C to +60 °C
Power Consumption	3mA
Operating Voltage	5V DC

Temperature-Humidity Sensor (DHT11):

Table 4.2 Temperature-Humidity Sensor (DHT11) Performance Parameters [19]

Sensing Range	20-90% RH
Accuracy	±5% RH
Temperature Range	0-50 °C
Temperature Accuracy	±2% °C
Operating Voltage	3V to 5.5V

PIR Sensor:

Table 4.3 PIR Sensor Performance Parameters [14]

Sensing range	less than 120 degree, within 7 meters
Trigger methods	L - disable repeat trigger, H - enable repeat trigger
Delay time	Adjustable (.3->5min)
TTL output	3.3V, 0V
Power Consumption	65mA
Operating Voltage	5V – 20V

PH Sensor:

Table 4.4 PH Sensor Performance Parameters [18]

Sensing range	0-14PH
Operating Temperature	0-60 ℃
Accuracy	± 0.1pH (25 ℃)
Response Time	≤ 1min
Operating Voltage	5V

SCREENSHOTS: Screenshots of output at different stages are:

In Arduino Uno, DHT11 sensor collects and sends the data about humidity and temperature in percentage and Celsius respectively, soil moisture sensor gives a reading between 0-550 which we have mapped to a percentage scale, PIR sensor popularly known as the motion detection sensor senses the motion of an animal or human hence it is an ideal sensor for detecting invasions. So whenever there is an invader on the farm a notification is sent to the farmer. The digital buzzer is just a simple sound making module which makes sound on High/Low. On just changing the frequency for the buzzer the buzz sound changes. In this project, HIGH/LOW sound starts generating when obstacle enters the detecting range of PIR sensor and stops at exit of that obstacle and creates invasion alert for that obstacle.

The arduino sending the data values for the sensors as: Soil Moisture, Relative Humidity, Temperature, Reading from the first part of the PIR sensor and reading from the second part of the same.

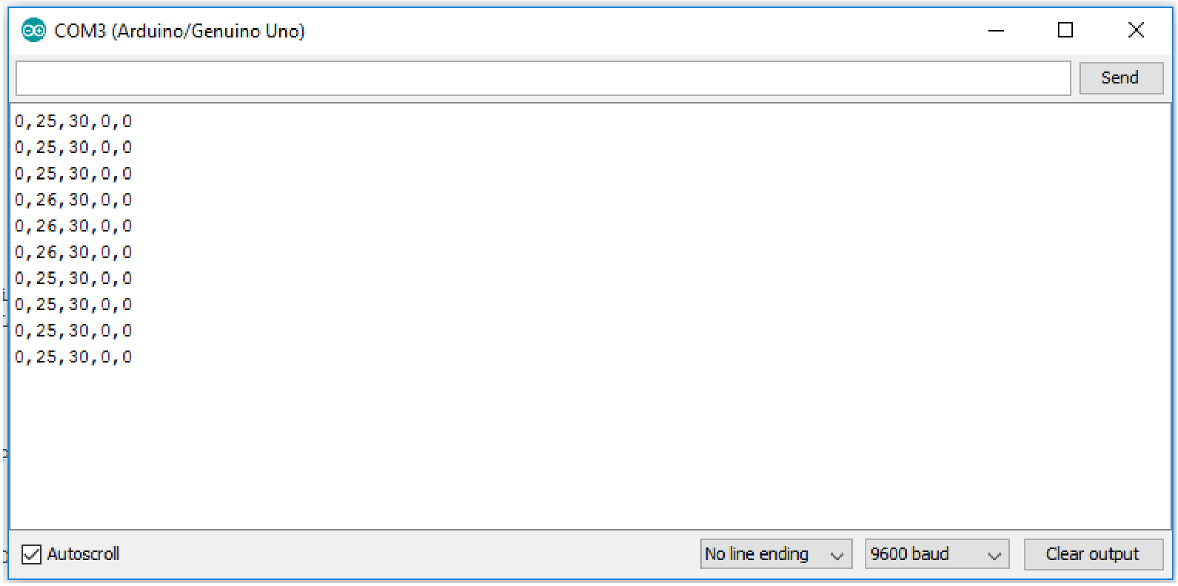

Figure 4.2 Arduino Code Output – 1

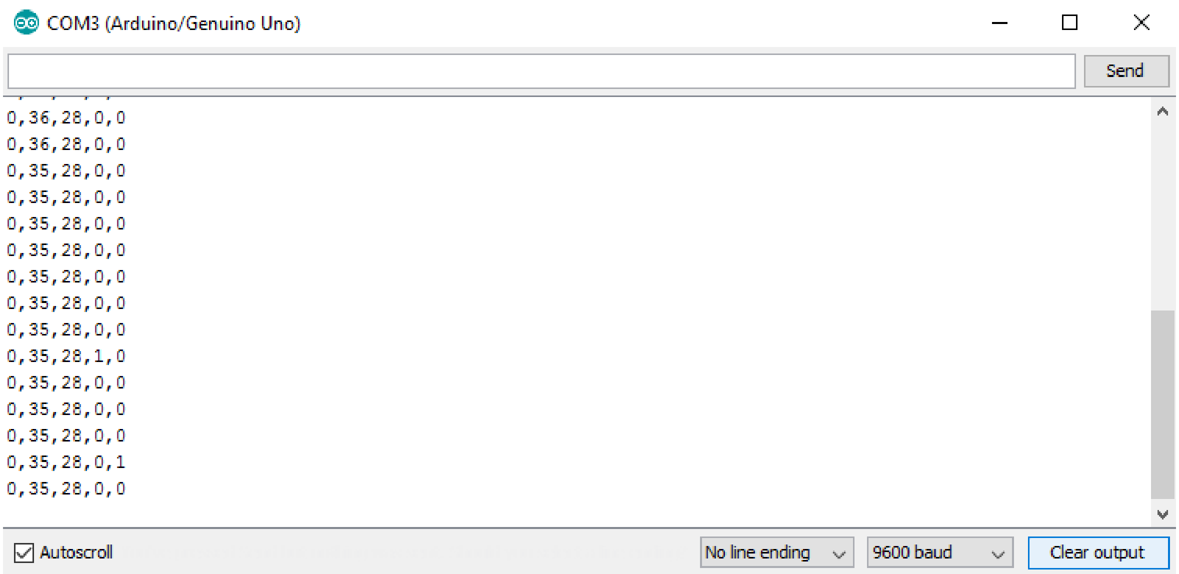

Figure 4.3 Arduino Code Output - 2

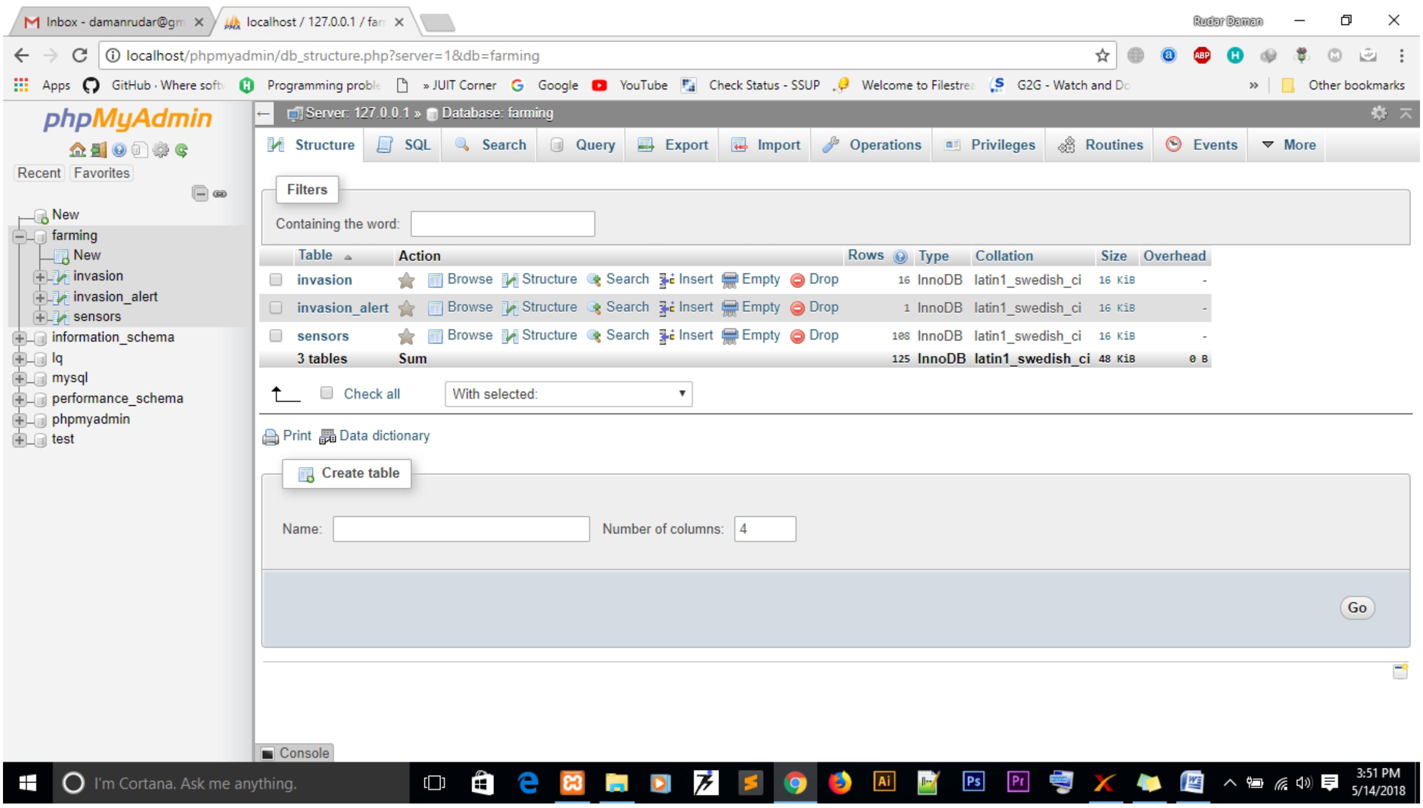

Figure 4.4 Farming Database – 1

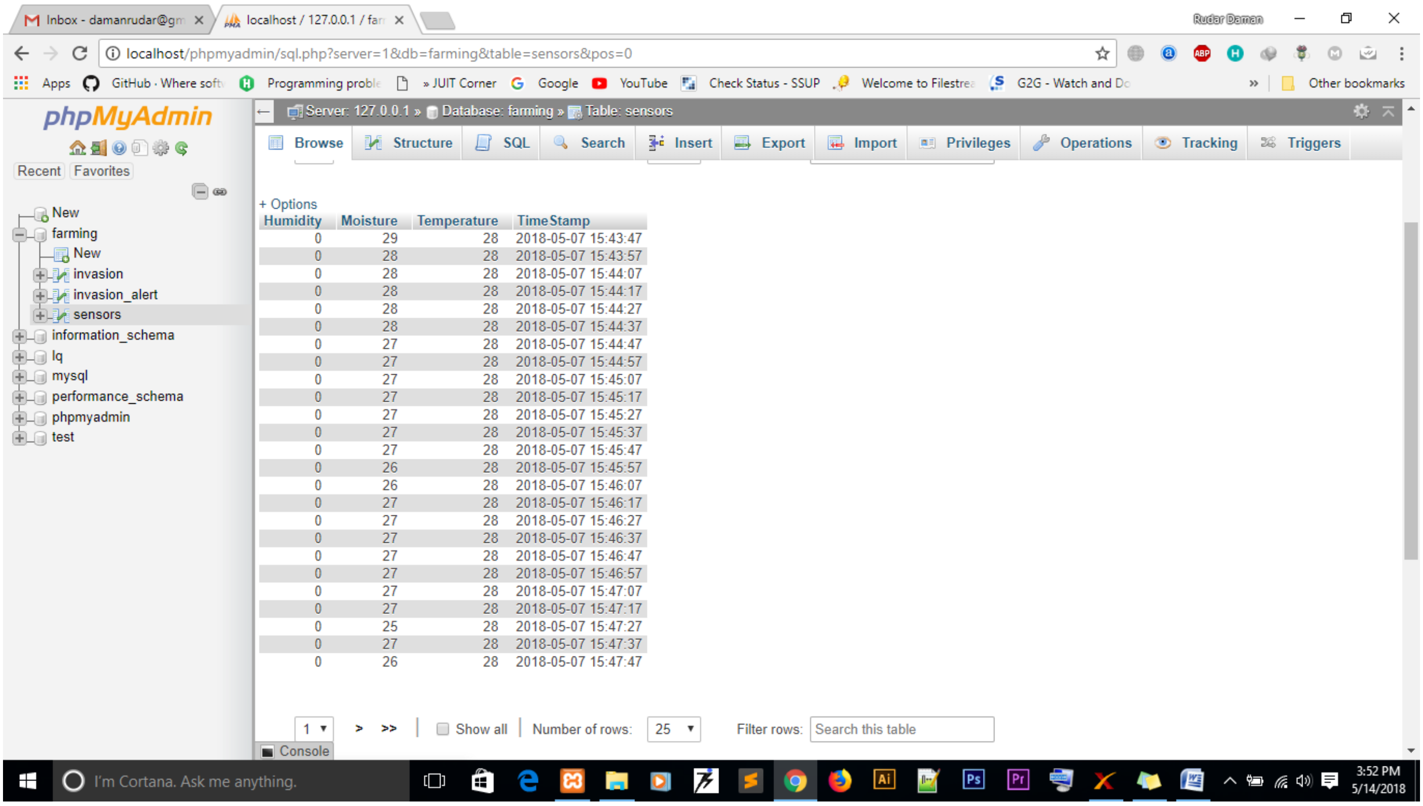

Figure 4.5 Farming Database - 2

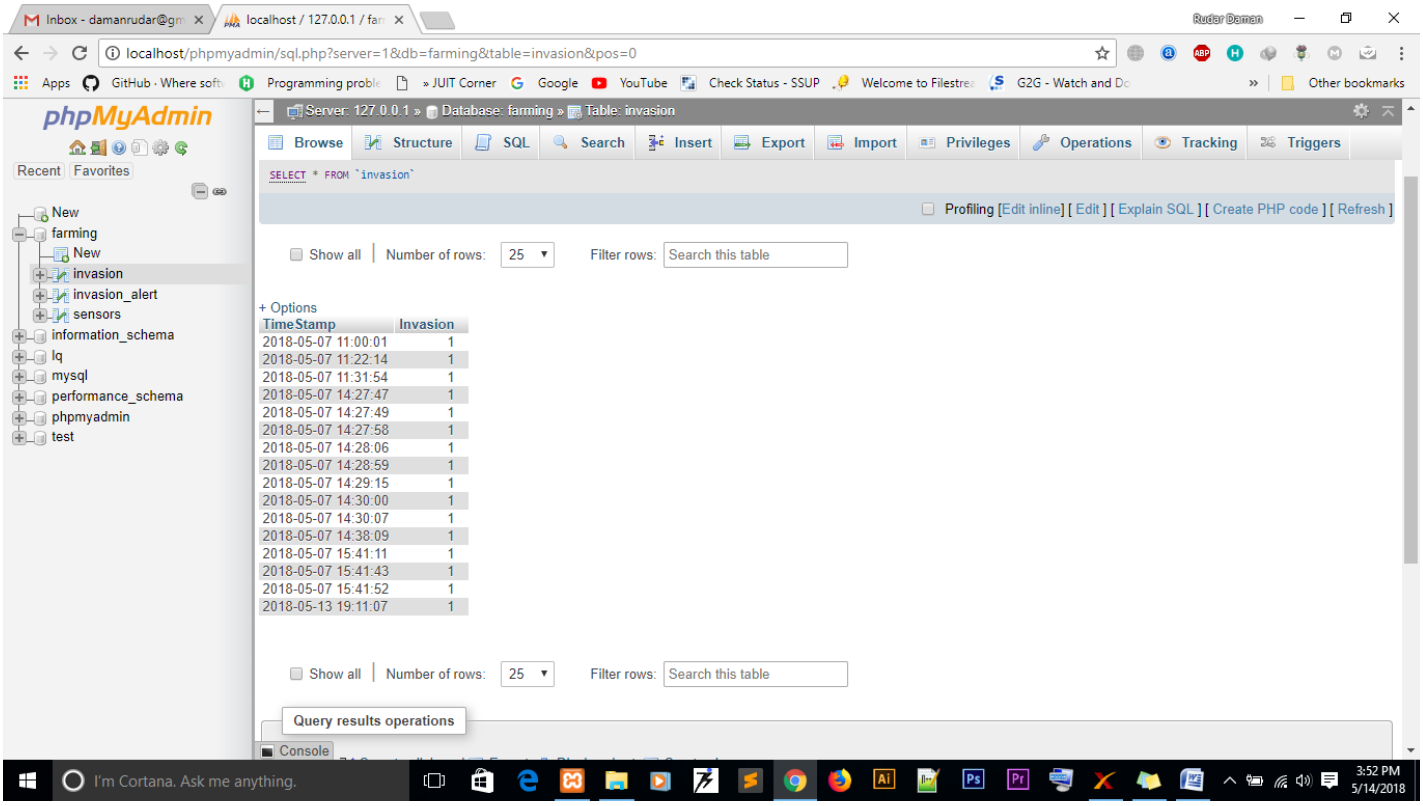

Figure 4.6 Farming Database - 3

The python script fetches these values from the arduino using the pySerial module via the serial port. The data is stored into the MySQL database using the pyScript. The MySQL database stores the data into the database tables created and then from there the PHP code fetches the data from the database. This data then travels to the web app where it is displayed and also based on the data received by the web app some decision based data travels back to the arduino board via the same route.

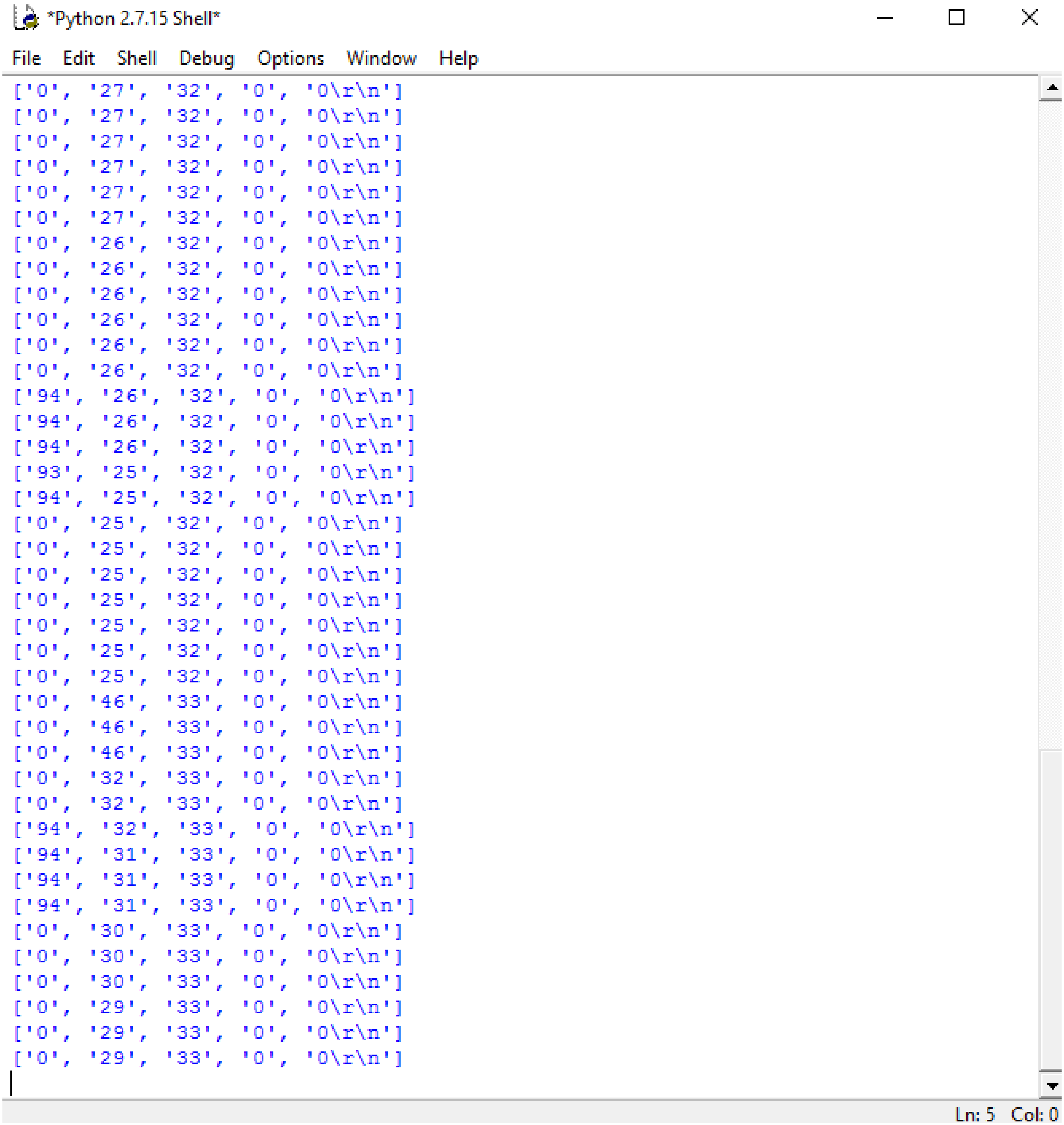

Figure 4.7 Python Code Output - 1

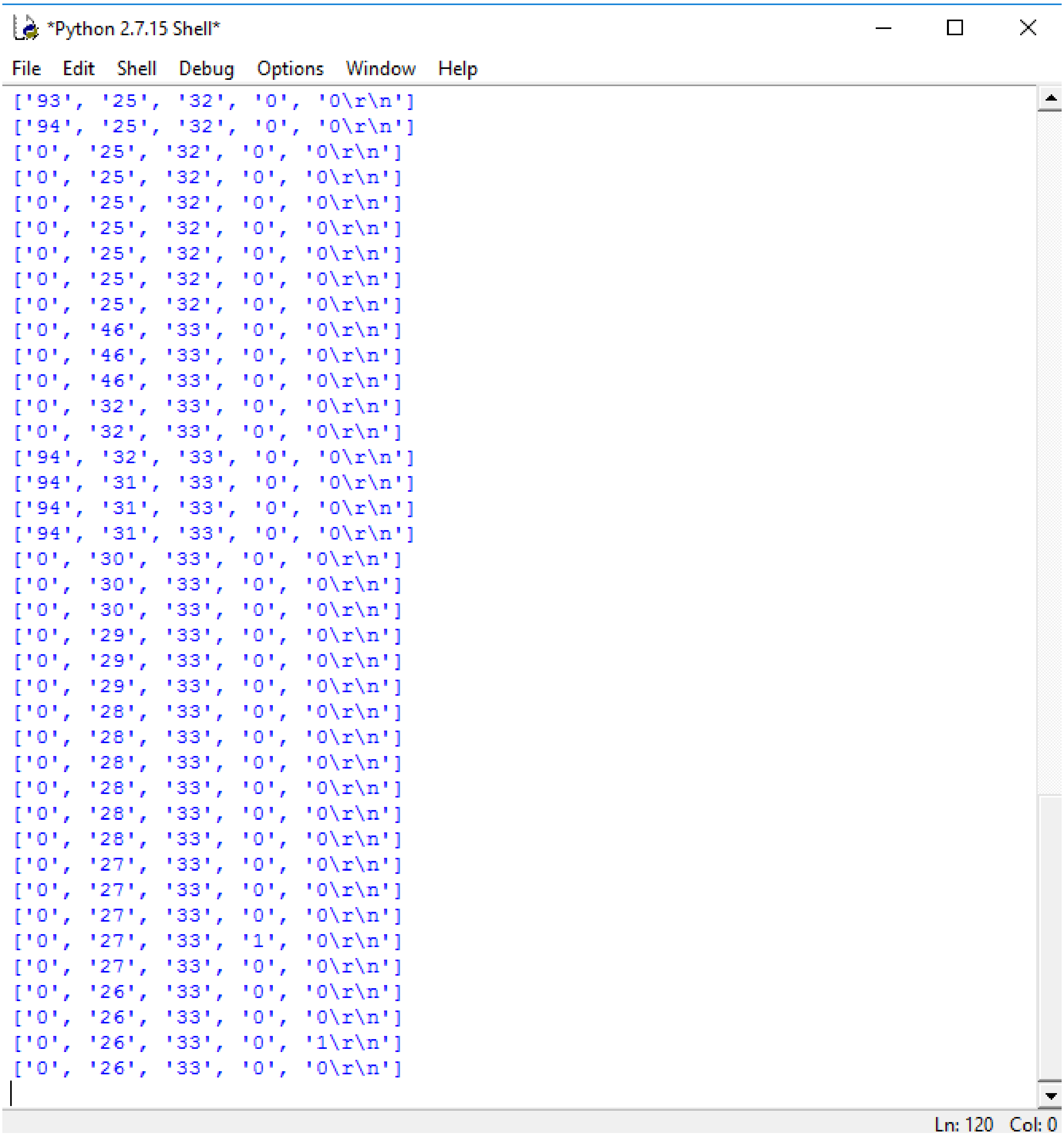

Figure 4.8 Python Code Output - 2

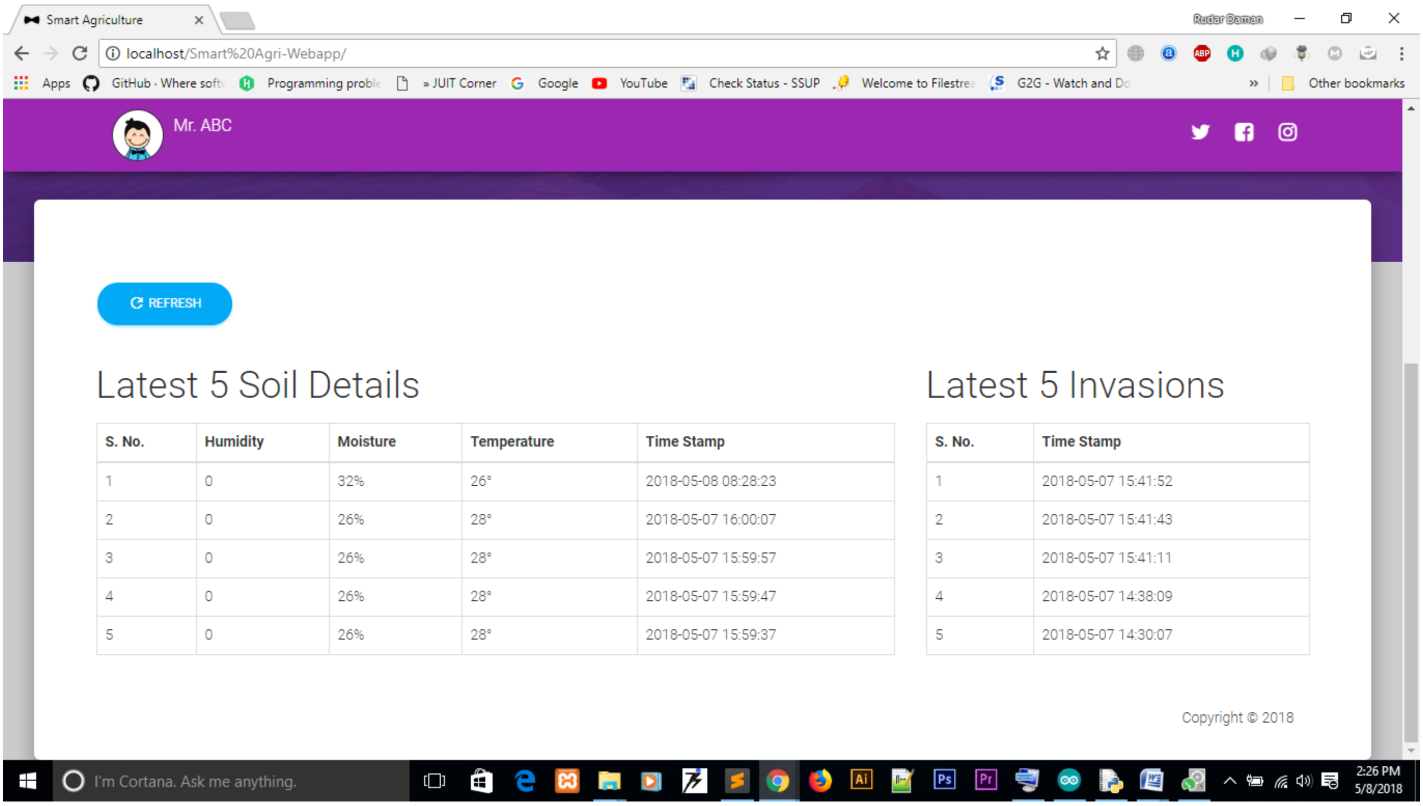

Figure 4.9 Web Application Readings - 1

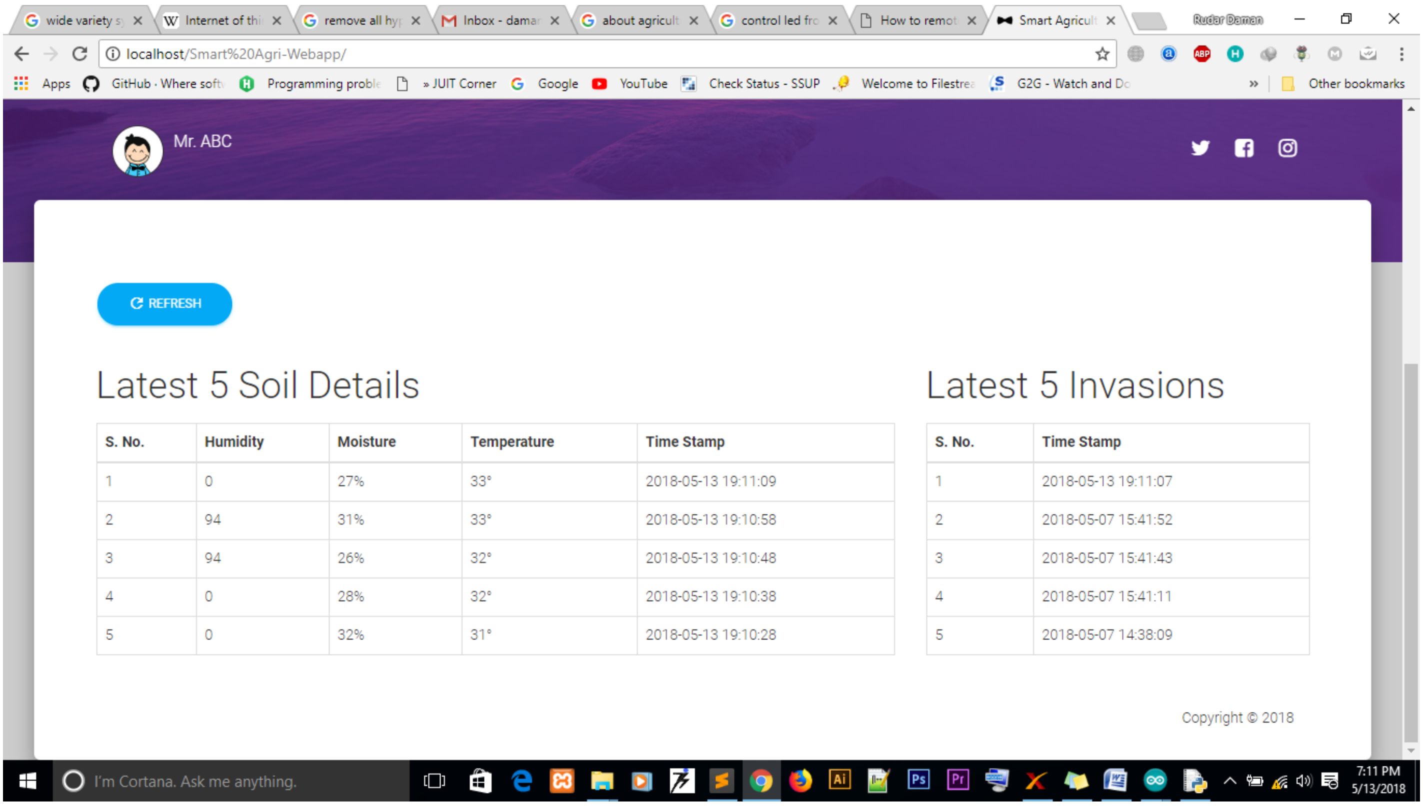

Figure 4.10 Web Application Readings - 2

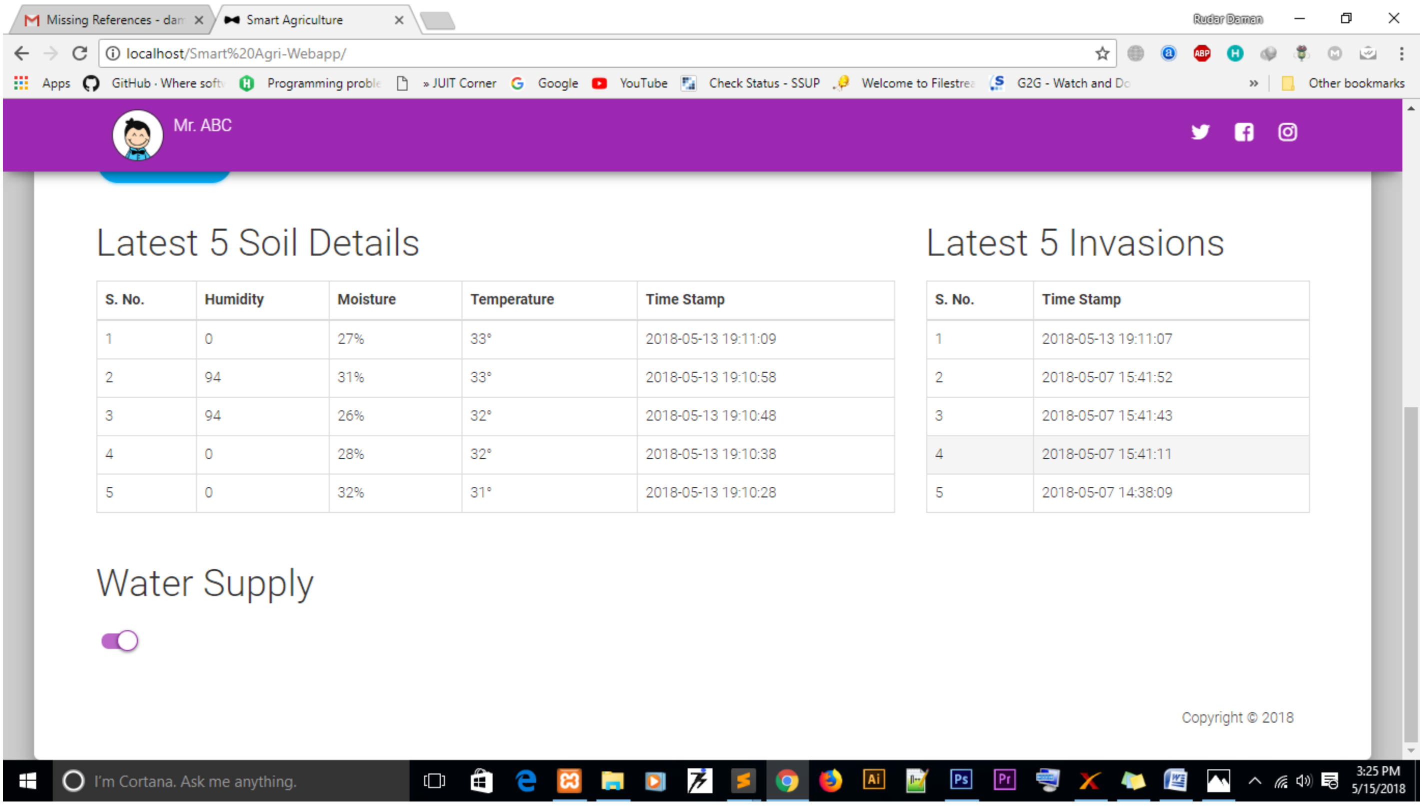

Figure 4.11 Web Application Readings - 3

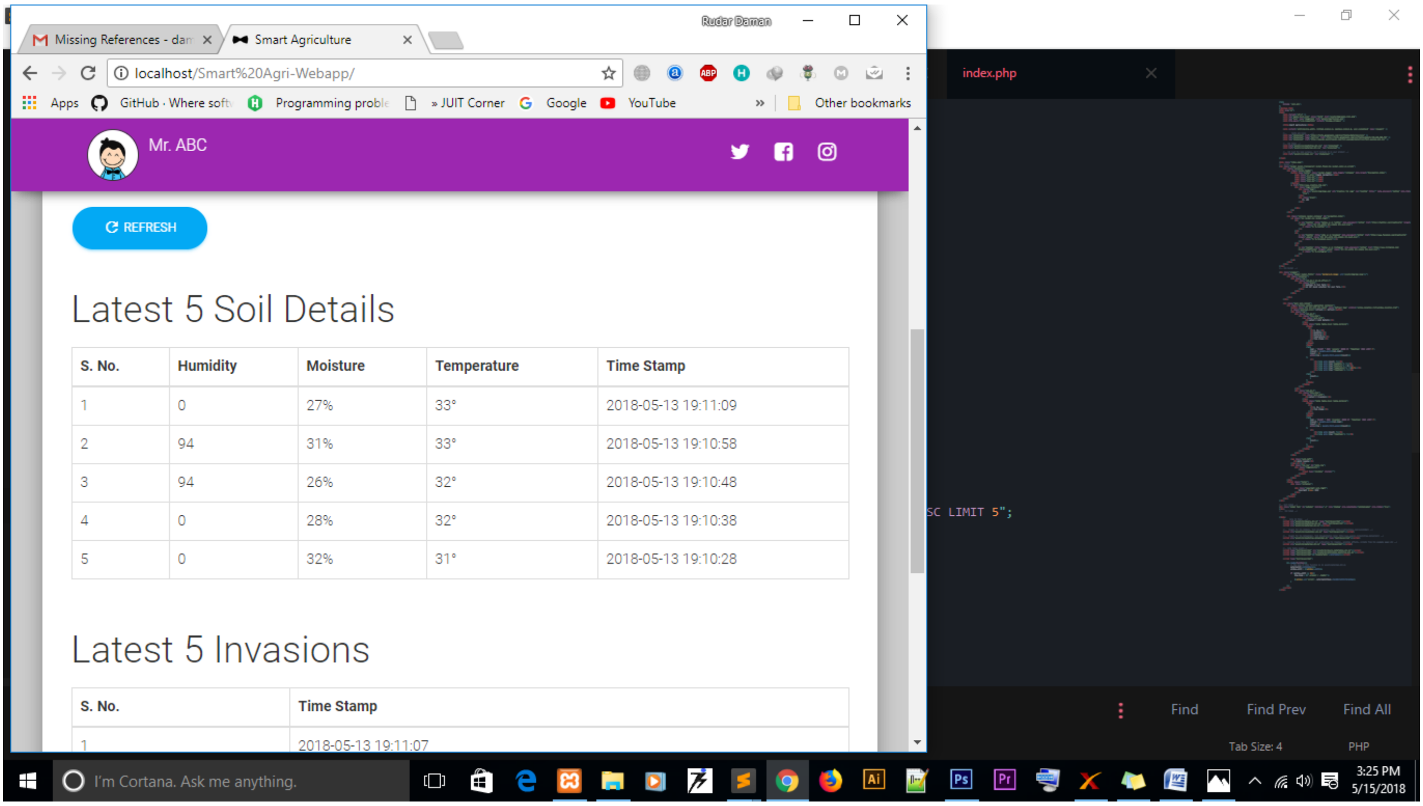

Figure 4.12 Responsive Web Application Readings - 1

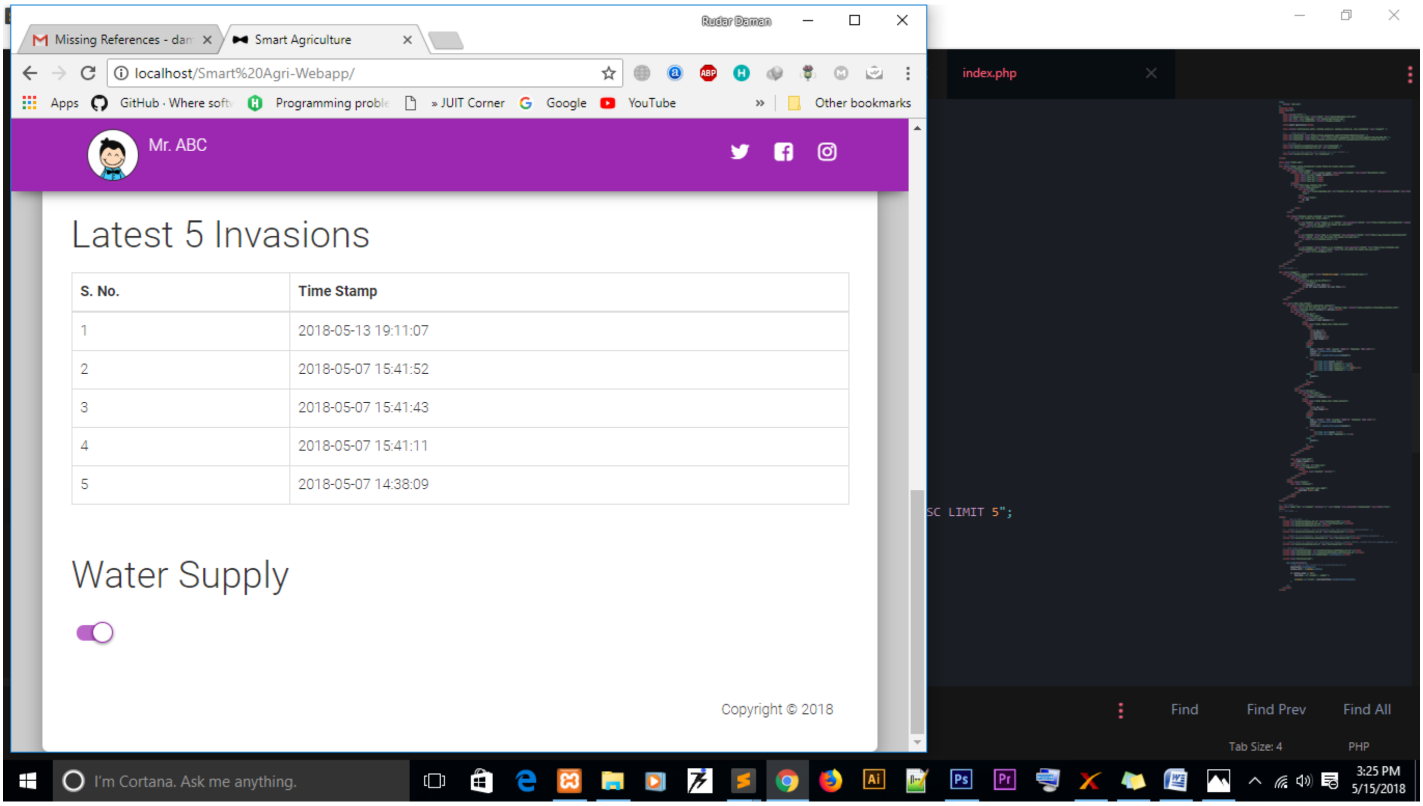

Figure 4.13 Responsive Web Application Readings - 2

Chapter-5

CONCLUSIONS

Conclusions

Thus with this system wastage of crop by straw animals, improper irrigation, and soil erosion can be avoided and further water wastage can be reduced. The major advantage of the system is that action of the system can be modified according to the situation. This system helps in irrigation of agricultural lands, parks, golf, gardens etc. In comparison with other automated systems, this system is reasonable and efficient. For large areas applications on large scale with high sensitivity sensors are implemented.

We made two basic conclusions which will be the basis of our further work, which are:

- The system should not be complex and it should be made as user friendly as possible.
- The cost should be minimized to the highest possible level.

Future Scope

The future scope of this project can be that the farms can be incorporated with sprinklers and the proposed system can undergo the required changes which help automation of water and pesticides needs of the soil accordingly.

Figure 5.1 Smart Irrigation System

The model can have modules which have more crop specific data and that too with state wise/region wise data which is necessary as all crops do not need same amount of water and pesticides in different climatic circumstances. So these changes can be incorporated into the proposed system in the coming times.

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