HARARE INSTITUTE OF TECHNOLOGY



DEPARTMENT OF INFORMATION SCIENCES

B. TECH [HONS] IN INFORMATION SECURITY AND ASSURANCE

IOT BASED SMART FARMING

BY

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HIT 400

*UNDER THE GUIDANCE OF*

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LECTURER POSITION, HARARE INSTITUTE OF TECHNOLOGY

*SUBMITTED IN FULFILMENT OF THE REQUIREMENTS OF B. TECH[HONS] IN*

INFORMATION SECURITY AND ASSURANCE

JUNE 2020

# CERTIFICATE

This is to certify that research work embodied in this dissertation entitled “IoT **Based Smart Farming”** was carried out by KUDZWAISHE SAMUVUMBA H160278Z studying at **HARARE INSTITUTE OF TECHNOLOGY** for partial fulfilment of Bachelor of Technology degree to be awarded by the Harare Institute of Technology. This research work has been carried out under my guidance and supervision and it is up to my satisfaction.

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**Signature and name of supervisor**

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Last but not least I am forever thankful to God for giving me strength, joy, peace and provision that has always been constant in my life. Everything would not have been possible without Him.

KUDZWAISHE SAMUVUMBA

# **Abstract**

**Farming has a major impact on the economy of the country. A lot of Research has been carried out in automating the farming system mainly focusing on the irrigation aspect. This project is going to be focused on smart farming as a whole, it is one thing to monitor the weather and soil conditions on a farm but it is another thing to control what happens with the data that has been captured. I have developed an IOT based smart farming solution using various sensors whereby farming conditions are not only monitored but a decision is made by the system on what to do with the data gathered based on the threshold values that have been set and the data is automatically updated on a Thinkspeak server and a website giving live feedback using graphs and charts. This is a unique and new approach unlike other methods introduced before. This project is aimed at improving the farming system to make it easier by automating it and controlling the variables on the farm.**

**Keywords: -**

**IOT – internet of things**

**Thinkspeak – an open-source Internet of Things application and API to store and retrieve data from things using the HTTP.**

**Sensors – devices that are frequently used to detect and respond to electrical or optical signals.**

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# CHAPTER 1: PROJECT PROPOSAL

## Introduction

smart farming is a management concept focused on providing the agricultural industry with the infrastructure to leverage advanced technology – including big data, the cloud, machine learning and the internet of things (IoT) – for tracking, monitoring, automating and analysing operations. Also known as precision farming, smart farming is software-managed and sensor-monitored.

### Problem statement

World population, as reported in June 2018, is a staggering 7.6 billion. It is estimated that this number will rise to 8.5 billion by 2030. With the rapid growth in world population, food consumption worldwide also grows rapidly. A rapid escalation in food production to cater to the growing demand is not an easy task.

Without automation in the farming sector, you cannot obtain data in real time which means they is no continuous monitoring and controlling of the chosen parameters. Farmers couldn’t access information of their farm remotely. Use of too much labour with low yielding results. Using too much resources such as water, fertilizers, seeds and chemicals which lead to high cost and pollution

## Objectives

* Develop an automated IOT based system which will be used in monitoring and controlling the crop field with the help of sensors Ph, humidity, temperature and soil moisture
* To create a web based application which enables the farmer to access data remotely in order to see what is happening on the farm
* Design a web server that stores the data from the sensors and sends the data in real-time to the web application

## Literature Review

* + 1. **AgriSys: A Smart and Ubiquitous Controlled Environment Agriculture System**

In [1], they proposed a smart Agriculture System (AgriSys) that can analyze an environment and intervene to maintain its adequacy. The system had an easy-to-upgrade bank of inference rules to control the agricultural environment. AgriSys mainly looked at inputs, such as, temperature, humidity, and pH. The system also could deal with desert-speciﬁc challenges, such as, dust, infertile sandy soil, constant wind, very low humidity, and the extreme variations in diurnal and seasonal temperatures. The system also provided increased productivity, enhanced safety, instant interventions, and an advanced life style. The system made was ubiquitous as it enables distant access.

* + 1. **Design and Implementation of a Connected Farm for Smart Farming System**

In [2], they made a connected farm based on IoT systems for smart farming systems. They have used IoT to provide Internet connectivity for the sensors and controllers of the connected farm, they have deployed the Cube, a standardized device software platform for IoT devices. They also have used the Mobius, an IoT service platform (also oneM2M-compliant) that provides REST APIs with which the data collected from sensors (e.g., CO2 sensor)can be retrieved, but also the control commands can be sent to controllers (e.g., air conditioner). They had implemented a smart phone application that allows end users to remotely monitor and control their connected farm, e.g., turn on air conditioner by pushing a button on the smart phone.

* + 1. **Smart Farming using Bluetooth wireless transmitter**

Research [3] been carried out by employing Bluetooth Wireless Transmitter that sense soil moisture, temperature etc and accordingly send the data to the Base station (BS) which makes the decision towards irrigation decision based on field and time. The irrigation control unit which is responsible towards irrigating the field pertaining to operating the sprinkler would receive the control signal from the BS. This is based on water Requirement of the fields. Some researchers are also working towards Variable rate Sensor based Irrigation System.

* + 1. **An Automated field specific irrigation system**

Researchers Wall and King [4] developed an automated field specific irrigation system with soil moisture sensor and sprinkler valve controller. These systems do not take into consideration monitoring the water pollution in lakes or rivers and also do not consider M2M Communication concept. Research been carried out in developing an intensive sensor based irrigation monitoring system which is scalable and self organizing.

* + 1. **Machine Learning in Agricultural Monitoring**

The machine learning algorithm has various uses in the field of agriculture monitoring which are being discussed here. In one of the research [5], Machine learning been applied towards Grape cultivation. In here farmers are unable to identify the disease manually on the grapes. The disease on grapes is identifiable only after the infection which takes lot of time and also has adverse effect on the vineyards. So accordingly a monitoring system developed for grape cultivation where temperature, relative humidity and leaf itness sensors are deployed in the vineyard. The data collected at regular intervals are sent using Zigbee module to the server. The server here employs the hidden markov model algorithm towards training the data sets pertaining to Temperature, relative humidity and leaf itness for analysing the data towards predicting the chance of disease on grapes before getting infected. This information is sent as alert message via sms to the farmer and expert. The system employs machine learning in early and accurate detection of disease in grapes and suggests pesticide to protect the crop from disease and reduce manual disease detection efforts. Also this system can be helpful for farmer’s towards giving information on schedule of fertilizer’s, pesticide spraying, irrigation etc which would help in improving the quality and quantity of grapes.

* + 1. **Automated irrigation system (A2S)**

Research [6] also been carried out by developing an automated irrigation system (A2S) which is based on sensor network. Wireless sensors are being employed for monitoring and controlling the agricultural fields. The management sub system controls the sensor network and accordingly provides service to farmer’s by means of PDA. In this system, long distance communicated provided by means of WLAN betien sensor network and server. Management subsystems consist of database, application and ib server. Data from sensors are received by the application server which are stored in the database server. Ib server is accessed by farmer’s using PDA.

# CHAPTER 2: REQUIREMENTS ANALYSIS

## 2.1. Feasibility Study

A **feasibility study** is an evaluation and analysis of a project or system that somebody has proposed. I also call it a **feasibility analysis**. The study tries to determine whether the project is technically and economically feasible. Economically feasible, in this context, means whether the project is feasible within the estimated cost.

A feasibility study also determines whether a project makes good business sense. Put simply; the study is an analysis of how easily or successfully i could complete something. It also tries to determine how profitable or unprofitable it might be.

### 2.1.1. Technical Feasibility

It is where we assess the software and hardware requirements that are needed to deliver my system. The requirements vary according to a specific system.

Below is a list of hardware and software requirements for my project

Table : software and hardware requirements

|  |  |
| --- | --- |
| **Hardware** | **Software** |
| Node MCU 32 | C programming language |
| Ph sensor | Think speak |
| Temperature Sensor | Arduino micro controller |
| Moisture Sensor | Html 5 and CSS3 |
| Soil Moisture Sensor |  |
| Copper Board 10\*15 |  |
| Solenoid Valve |  |
| Female Header 40 Pin |  |
| Male Header 40 Pin |  |
| Humidifier |  |
| 4 Channel Relay |  |
| Mini Aquarium Water Pump |  |
|  |  |

The requirements are to facilitate the production of the required output in a given space of time. They speed up the response time and deliver the required results

Given the requirements and the technical resources available it shows that the project is feasible.

### 2.1.2. Economic Feasibility

320

HIREMATH et al., Curr. Agri. Res., Vol. 5(3), 318- 324 (2017)

number of farmers who adopted precision farming for

paddy was 38. Primary data ire collected from the

farmers who adopted precision farming techniques in

paddy since last three years. The data ire collected

from the sample farmers by personal interview

method using the pretested schedule during the

period of January and February for the agricultural

year 2014-15.

The data collected ire analyzed by using tabular

analysis as ill as ﬁnancial feasibility measures.

The technique of tabular presentation was employed

to assess the cost, returns and proﬁts of paddy

cultivation. The data ire summarized with the

aid of statistical tools like percentage, averages

etc. to draw meaningful inferences. To evaluate the

economic viability of an investment in precision

farming techniques at the farm level, financial

feasibility analysis was carried out by using following

measures:

i. Net Present Value (NPV): The cash flow

stream is iighted by the discount rate and

then it becomes the discounted cash ﬂows.

The positive value of NPV is the criteria for

selection of the project/ investment. NPV was

estimated by using the formula,

Where, Bt= Discounted benefits, Ct =

Discounted costs, t = time period, r =

discount rate, n= number of years, I= initial

investment

ii. Beneﬁt- Cost Ratio (B: C ratio): It attempts to

identify the relationship betien the costs

and beneﬁts of the project. It is the ratio of

beneﬁts of the project to the costs, expressed

in monetary terms, which are discounted at

Table 1: Cost and returns structure in adoption of precision farming in paddy

( /ha)

Sl. Particulars Amount Percentage contri-

no. ( /ha) bution to total cost

COST

I Total variable cost

1 Material input cost 15904.97 20.98

2 Labour cost 39115.62 51.59

3 Marketing cost 805.86 1.06

4 Interest on working capital @9% 5024.38 6.63

Sub total 60850.83 80.25

II Total ﬁxed cost

1 Depreciation 792.71 1.05

2 Land rent 10875 14.34

3 Land revenue 175 0.23

4 Interest on ﬁxed capital @11.25% 1332.3 1.76

Sub total 13175.01 17.38

A Total cost of cultivation(I+II) 74025.84 97.63

B Management cost 1799.51 2.37

Total cost (A+B) 75825.35 100

RETURNS/ REVENUE

1 Yield (q) 75.55 -

2 Gross returns 122656.3 -

320

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B Management cost 1799.51 2.37

Total cost (A+B) 75825.35 100

RETURNS/ REVENUE

1 Yield (q) 75.55 -

2 Gross returns 122656.3 -

Methodology

The study was conducted in North Eastern Karnataka

region of Karnataka state in the jurisdiction of

UAS, Raichur. Hoiver, the study area conﬁned

to village Jangamarakalgudi of Gangavathitaluk,

Koppal district of North Eastern Karnataka as

RKVY- Precision Farming project for paddy has been

implemented in that district. The sample farmers

under study for the present paper includes only the

precision farming adopted farmers (the beneﬁciaries

of precision farming project of UAS, Raichur). The

The study was conducted in Harare south, Nyatsime district on a plot with loamy soil. IOT based smart Farming project will be implemented in this district. Primary data is collected from the farmers who adopted precision farming techniques in other countries with similar weather, soil and economic conditions in the last three years.

The data collected were analysed by using tabular analysis as well as financial feasibility measures. The technique of tabular presentation was employed to assess the cost, returns and profits of paddy cultivation. The data is summarized with the aid of statistical tools like percentage, averages etc. to draw meaningful inferences. To evaluate the economic viability of an investment in precision farming techniques at the farm level, financial feasibility analysis was carried out by using following measures:

1. Net Present Value (NPV): The cash flow stream is highted by the discount rate and then it becomes the discounted cash flows. The positive value of NPV is the criteria for selection of the project/ investment.
2. Benefit- Cost Ratio (B: C ratio): It attempts to identify the relationship between the costs and benefits of the project. It is the ratio of benefits of the project to the costs, expressed in monetary terms, which are discounted at the present value. The criteria for preferred project is B: C ratio of more than unity when costs and benefits ire discounted at the opportunity cost of capital
3. Internal Rate of Return (IRR): It is the discount rate which makes NPV of all the cash flows from the particular project is equal to zero.
4. Payback period (P): It is the length of time required for the investment to recover its initial investment made in the project. It was estimated by ratio of investment of the project to annual net cash revenues
5. Profitability index (PI): It is the investment appraisal technique calculated as the ratio of present value of future cash flows to the initial investment of the project.

Table : Forecasted Profit and loss statement for smart farming in Nyatsime for year 2021

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl.  no.** | **Particulars** | **Amount**(`/ha) | **Percentage contribution to total cost(usd)** |
| **COST** | | |
| I | Total variable cost | |  |
| 1. | Material input cost | 15904.97 | 20.98 |
| 2. | Labour cost | 39115.62 | 51.59 |
| 3. | Marketing cost | 805.86 | 1.06 |
| 4. | Interest on working capital @ 9% | 5024.38 | 6.63 |
| Sub total | | 60850.83 | 80.25 |
| II | Total fixed cost | |  |
| 1. | Depreciation | 792.71 | 1.05 |
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| 3. | Land revenue | 175.00 | 0.23 |
| 4. | Interest on fixed capital @ 11.25% | 1332.30 | 1.76 |
| Sub total | | 13175.01 | 17.38 |
| A | Total cost of cultivation(I+II) | 74025.84 | 97.63 |
| B | Management cost | 1799.51 | 2.37 |
| Total cost (A+B) | | 75825.35 | 100.00 |
| **RETURNS/ REVENUE** | | |  |
| 1 | Yield (q) | 75.55 | - |
| 2 | **Gross returns** | 122656.30 |  |

#### Assumptions for this study

* Useful life of the sensors and hardware requirements used was assumed as ten years.
* Area under cultivation in Nyatsime was assumed to remain same up to ten years.
* The benefits from the smart farming technology will be realized from the very first year of implementation of the technology
* Technology remains constant over the time period.
* Discount rate of 15 per cent was assumed as the opportunity cost of capital at which stream of cash flow is discounted.
* The costs and the gross returns ire assumed to be unchanged from first to tenth year.

## 2.2. Requirements Analysis

Requirements analysis, also called requirements engineering, is the process of determining user expectations for a new or modified product. These features, called requirements, must be quantifiable, relevant and detailed. In software engineering, such requirements are often called functional specifications.

### 2.2.1. Functional Requirements

A functional requirement defines a system or its component. It describes the functions a software must perform. A function is nothing but inputs, its behaviour, and outputs. It can be a calculation, data manipulation, business process, user interaction, or any other specific functionality which defines what function a system is likely to perform. Functional software requirements help you to capture the intended behaviour of the system. This behaviour may be expressed as functions, services or tasks or which system is required to perform.

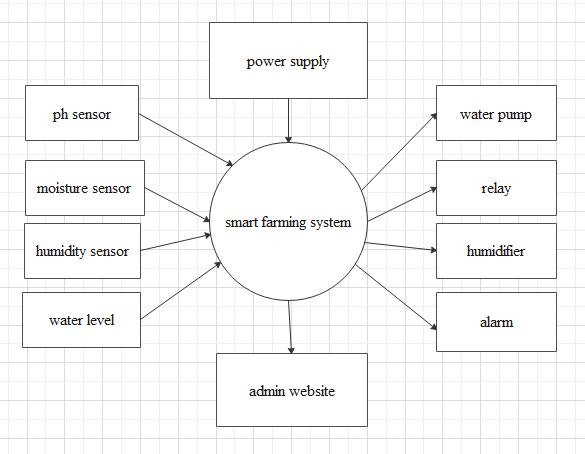
I have developed an IOT based smart farming solution using the following sensors Ph, Temperature, Humidity, Water level and Soil Moisture) so data from the sensors is sent to the micro controller and it is checked against the threshold values set for the cabbage plant and based on the threshold values that have been set the actuators (relay, water pump, humidifier and the alarm) either turn on/off and the data is automatically updated on the Thinkspeak server and the local web server in the form of a linegragh.

Table : Functional Requirements Analysis

|  |  |
| --- | --- |
| **Criterion** | **Requirements** |
| Action initialization | Ability to simulate real world conditions and initialise the testing process |
| Detection of IOT devices | Ability to detect all of the IOT devices within the system |
| Adding and removing a test case | Ability to add/remove a test case in the system (test cases are different types of security vulnerabilities). |
| Automatically running a test case. | Ability to run the test case automatically with minimal or no intervention for all connected devices. |
| Logging the status of each test case | Ability to log the status of each test case in real-time. |

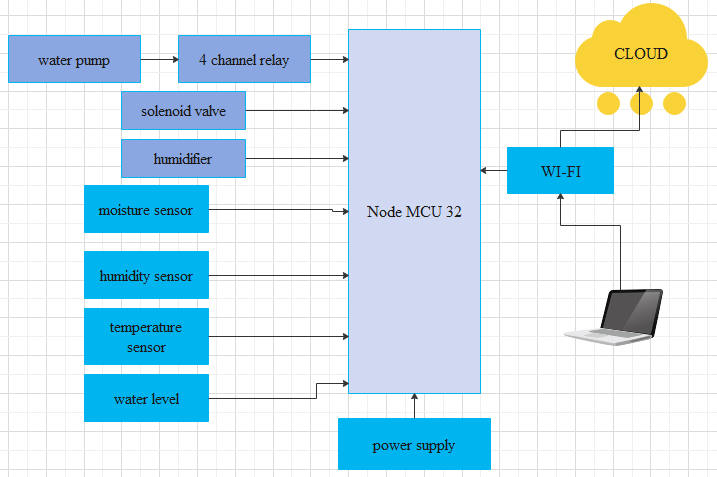
#### 2.2.1.1. Context Level DFD

Figure : Context level DFD



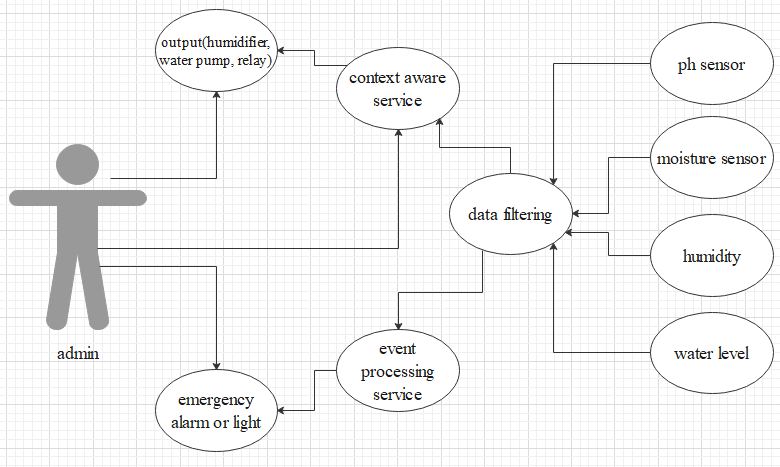
#### 2.2.1.2. DFD Level 1

Figure : DFD Level 1



#### 2.2.1.4. Use Case

Figure : Use Case



### 2.2.2. Non-Functional Requirements

a non-functional requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviours. They are contrasted with functional requirements that define specific behaviour or functions.

#### 2.2.2.1. Performance

This is the ability of the speed of operation of the system. Performance requirements pertain to:

1. throughput requirements which define how much the system can accomplish within a specified amount of time
2. response requirements which define how quickly the system reacts to user input.

#### 2.2.2.2. Usability

Usability ensures the system’s ease of use, without the need for extensive efforts on the part of the user. Security system should be easy to operate and use (with easily defined tests, easy to input configuration and to interpret output).

This system is very user friendly and easy to understand, a farmer from the village can easily understand this system and its functionality.

Flexibility: is the capability to modify the system after deployment. This includes:

1. adaptability, the ability of the system to be adapted based on new requirements and application domain concepts;
2. sustainability, the ability to fix faults and deal with new technology
3. customizability, the capability of the system configuration to be customized and fine-tuned by the user.

#### 2.2.2.3 Security

* Reliability: is the ability of the system to perform its required functions under the stated conditions for a specific period of time. Furthermore, reliability can be considered as:

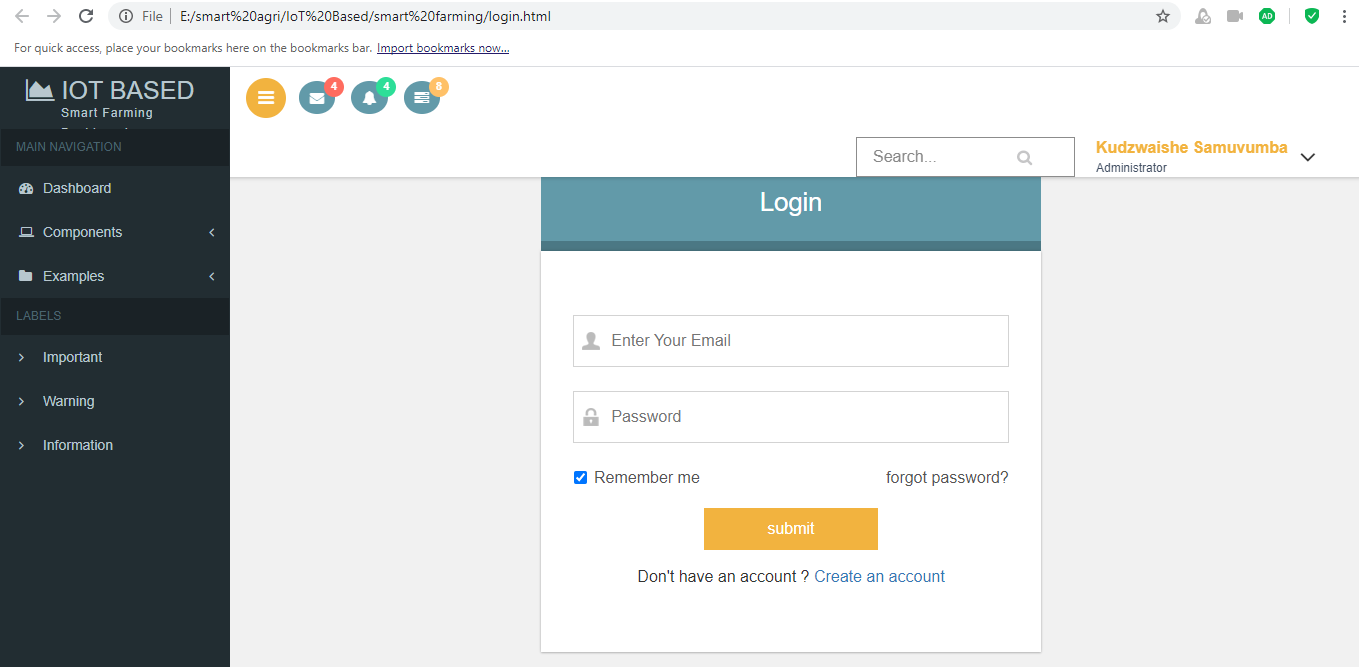
1. the availability of the system service when requested by end-users
2. the failure rate which is how often the system fails to deliver the service requested by the users.

* Anti-Forensic: is the capability of the system to detect and subsequently prevent malicious applications on the iot devices (if it has been infected) from being activated. Malicious applications, in particular, tend to disturb the forensic analysis operation, and the system should be able to prevent the IoT devices from being activated to overwrite any sensitive data that shouldn't fall into the wrong hands.
* Accountability (including non-repudiation): is the capability of the system to keep audit records to support independent review of access to resources/uses of capabilities – not only the data collected, but also the log files must be specified and protected.
* Controlled: is the ability of the system to prevent malicious IoT devices from being activated.

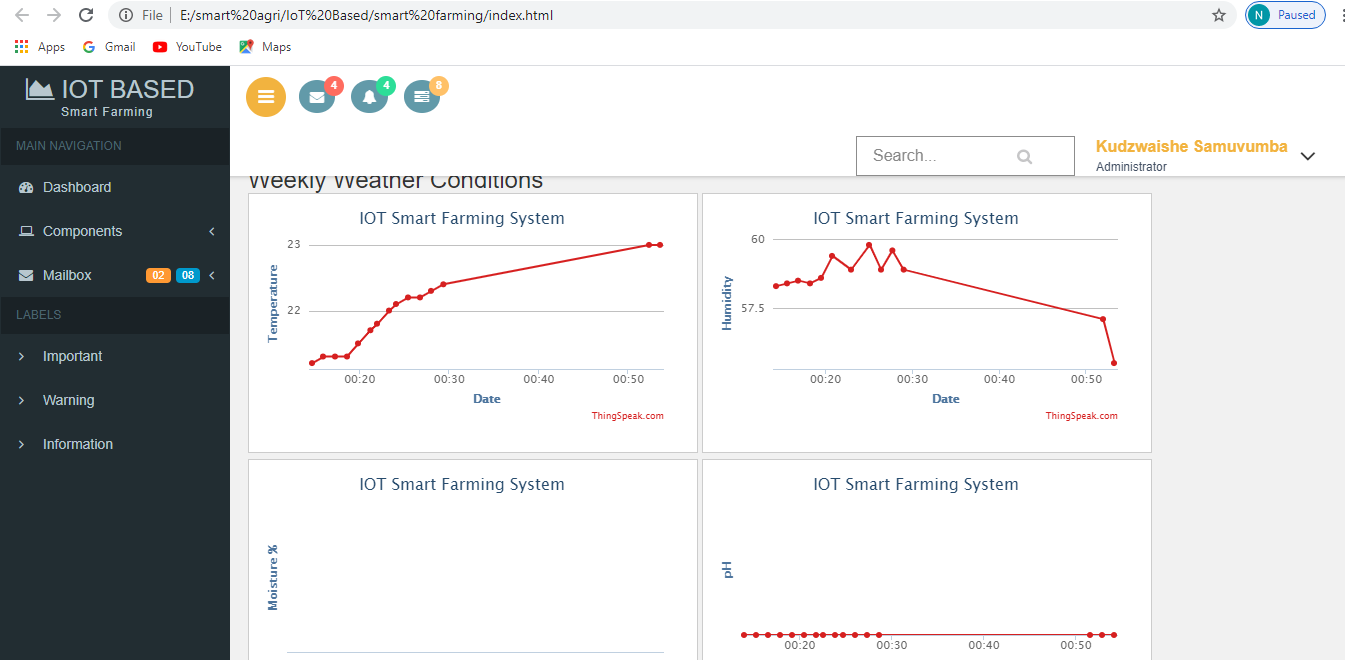
### Interface Requirements

USER INTERFACE REQUIREMENTS

1. The user (farmer) should be able to login to his/ her website



1. The user (farmer) should be able to see the graphical representation of the data being collected in the field on the website



### 2.2.4. Technical Requirements

Table : Software and hardware requirements

|  |  |
| --- | --- |
| **Hardware** | **Purpose for requirement** |
| Node MCU 32 | a low-cost open source IoT platform |
| Ph sensor | To measure the ph of the water |
| Temperature Sensor | To measure the temperature in the farm |
| Soil Moisture Sensor | To measure the moisture in the soil |
| Copper Board 10\*15 | To connect the devices |
| Solenoid Valve | an electrically controlled valve used to open and close |
| Female Header 40 Pin | Connect components |
| Male Header 40 Pin | Connect components |
| Humidifier | To increase the humidity in the farm |
| 4 Channel Relay | used to control high voltage, high current load such as motor, solenoid valve. |
| Mini Aquarium Water Pump | To pump the water to the farm when its needed |
|  |  |

|  |  |
| --- | --- |
| **Software** | **Purpose for requirement** |
| C programming language | To develop the system |
| Think speak | Used to store and retrieve data from things using the HTTP |
| Arduino micro controller | create interactive electronic objects. |
| Html 5 and CSS3 | To develop the User interface |

### 2.2.5. Assumptions

* Useful life of the equipments used was assumed as ten years.
* Area under cultivation in Nyatsime was assumed to remain same up to ten years.
* The benefits from the smart farming technology will be realized from the very first year of implementation of the technology
* Technology remains constant over the time period.
* Discount rate of 15 per cent was assumed as the opportunity cost of capital at which stream of cash flow is discounted.
* The costs and the gross returns is assumed to be unchanged from first to tenth year.

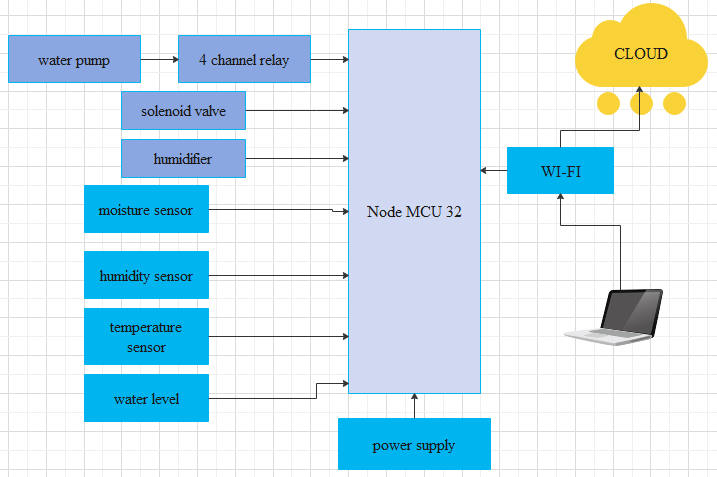
# CHAPTER 3: DESIGN

## 3.1. Proposed Solution

To automate the farming operations, several environmental parameters have to be considered, particularly those that have impact on farming. The important environmental parameters include temperature, humidity, moisture, soil moisture, ph and water level. Different types of sensors are deployed over the field to monitor those environmental parameters related to farming and attached with microcontroller. According to environmental condition, microcontroller controls different actuators or farming equipment (Water Pump, Relay, Solenoid Valve, Alarm) without human intervention. Apart from that these sensed data can be stored in the cloud. Microcontroller attached with wi-fi module sends those sensed parameters to the cloud.

## 3.2. Solution Architecture

Figure : Solution Architecture



## 3.3. Constraints

The two main constrains of this project are time and money as the project is supposed to be completed within a stated time frame and the money required to buy the hardware components is needed for the project prototype.

## 3.4. Security design

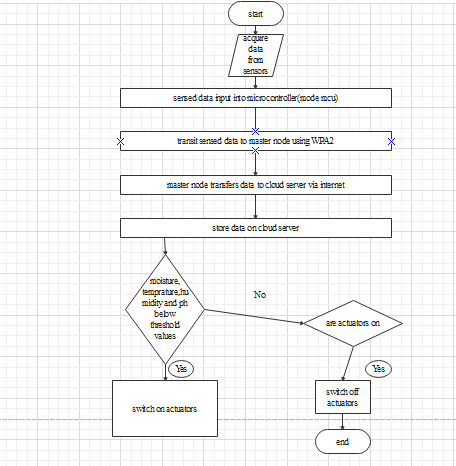
The security design in this system includes:

1. the availability of the system service when requested by end-users
2. the system needs to detect and subsequently prevent malicious applications on the iot devices

## 3.5. System Design Models

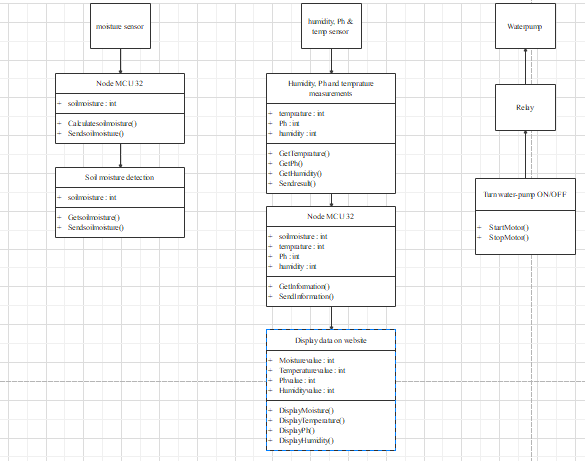
### 3.5.1. UML – Activity Diagram

Figure : Activity Diagram



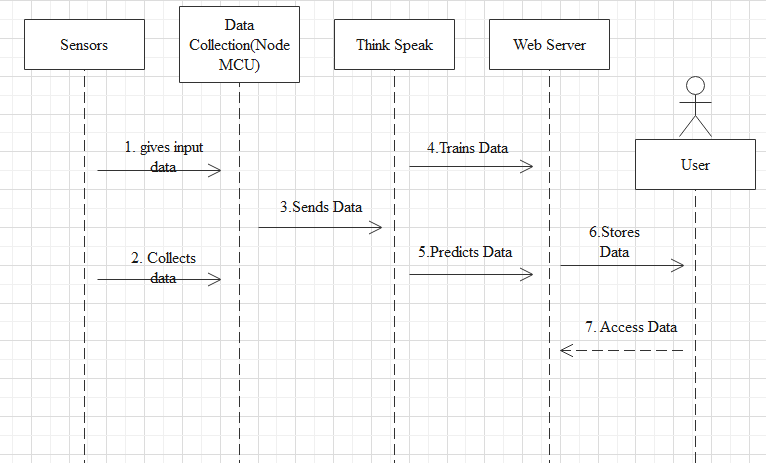
### 3.5.2 UML – Class Diagram

Figure : Class Diagram



### 3.5.3. UML – Sequence Diagram

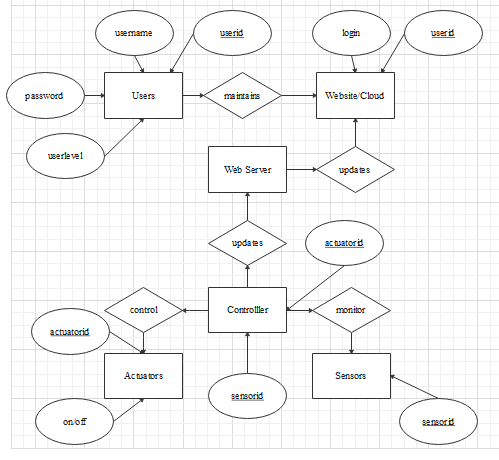
Figure : Sequence Diagram



## 3.6. Database Modelling

### 3.6.1. E-R Diagram

Figure : E-R Diagram



### 3.6.2 Algorithm design

Step 1:

Sensors are placed on the farm at appropriate site

Step 2:

Sensors collect data

Step 3:

The data is sent to the micro- controller NODE MCU 32

Step 4:

The micro-controller compares the sensed data to the threshold values set in the system

Step 5:

If the sensed data is above the threshold the actuators are turned on

Step 6:

If the sensed data is below the threshold the actuators are turned off

Step 7:

The data is then sent to the cloud server where it is stored and graphs are plotted

Step 8:

The data is then sent from the server to the web app where the farmer can access it

# 4. CHAPTER 4: IMPLEMENTATION

## 4.1. INTRODUCTION

Implementation is the process of putting the system into use in order to see how the system is functioning and also check if it meets the user requirements**.** It manly focuses on the conventions, coding strategies and the code review

## 4.2. Coding Conventions

Here we looked at set of guidelines for programming language (in this case i used C programming language) that recommend programming style, practices as well as methods for each aspect of a program written in that language. In order to come up with my system i followed C programming coding conventions and also using them as the following benefits:

1. You can change, copy and maintain a code more easily

2. You can ensure that your code demonstrates best practices

3. Readers are able to understand our code more quickly

4. The code has a consistent look so that readers can also focus on content

Arduino

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 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.

|  |
| --- |
|  |
| C:\Program Files (x86)\Arduino\reference\www.arduino.cc\en\uploads\Guide\export.png | Verify Checks your code for errors compiling it. |
| C:\Program Files (x86)\Arduino\reference\www.arduino.cc\en\uploads\Guide\new.png | New Creates a new sketch. |
| C:\Program Files (x86)\Arduino\reference\www.arduino.cc\en\uploads\Guide\open.png | 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. |
| C:\Program Files (x86)\Arduino\reference\www.arduino.cc\en\uploads\Guide\save.png | Save Saves your sketch. |
| C:\Program Files (x86)\Arduino\reference\www.arduino.cc\en\uploads\Guide\serial_monitor.png | Serial Monitor Opens the [serial monitor](file:///C:\Program%20Files%20(x86)\Arduino\reference\www.arduino.cc\en\Guide\Environment.html#serialmonitor). |

## 4.3. Coding Strategy

Under this section we look at the approaches used in coding the copyright protection using invisible digital image watermarking system.

|  |  |
| --- | --- |
| **Module** | Microcontroller |
| **Platform** | Windows 10 |
| **Language** | C |
| **IDE** | Arduino |
|  | |
| **Module** | Web Application |
| **Platform** | Windows 10 |
| **Language** | HTML 5 and CSS 3 |
| **Text Editor** | Sublime Text |

## 4.4. Coding Review

Before reviewing our code, we set up some rules for an efficient code review. These rule can be defined as:

* The code has to be reviewed before it is checked into the version control
* The review process is done manually
* The review process took time to be completed. The following techniques that were followed to review the code:
* Review less than 200 lines of code at a time
* Inspect the functionality of the system after every single modification to the code
* Take an adequate and proper time for reviewing a code of a certain functionality
* Annotate the newly added code whenever required (this was followed mainly when there was a need for a modification of a certain functionality or adding a new one)
* Establish a quantifiable goals for our code review
* Follow a checklist that is either based on (an) objective(s), functionality or a task
* Verify the proper functionality of a certain modification or a fix

|  |  |  |
| --- | --- | --- |
| **Questions** | **Yes** | **No** |
| Does the code completely and correctly implement the design |  |  |
| Does the code conform to any application standards? |  |  |
| Is the code well structured, consistent in style, and consistently formatted? |  |  |
| Are there any uncalled or unneeded procedures or any unreachable code? |  |  |
| Are there any leftover stubs or test routines in the code |  |  |
| Can any code be replaced by calls to external reusable components or library functions |  |  |
| Are there any blocks of repeated code that could be conducted into a single procedure |  |  |
| Are any modules excessively complex and should be restructured or split multiple routines |  |  |
|  |  |  |

## 4.5 Summary

The section generally focuses on the coding practices that should be put into use for effective implementation. This involves use of coding strategies, coding review and the coding review

# 5. CHAPTER 5: SYSTEM TESTING

## 5.1. Testing

Testing is implementing measures to verify and check the quality, performance, or reliability of our system before we can deploy it to the external world thus the customers or the end users. In order to check if our system is up to standard we ought to test it thus can subject a system to different kinds of environments.

## 5.2. Testing Categories and results

### 5.2.1. White box

It is the testing of the internal workings or code of a software application

### 5.2.2Black Box

Here we looked at the internal structure/design/implementation of my system. These tests can be functional or non-functional, though usually functional.

## 5.3. Types of Testing and results

### 5.3.1. Functional testing

Under this section we will be testing our software to see if it fully gives the assurance and also ensure that it fully conforms to all the requirements within software development. Functional testing is a way of inspecting a software to make sure that it has all the required functionality that's specified within its functional requirements and is also functional as to what is expected.

### Non-functional testing

This is testing the performance of our system or software application, its usability as well as how reliable it is. We also look at its security features, survivability, scalability, interoperability, flexibility and so on. It mainly designed in order to test the readiness of a system or a software application as to the functional requirements which would have been aligned under functional requirements testing. An excellent example of non-functional test would be to check how many people can simultaneously login into a software.

## Test cases

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Case** | **Steps to execute the test case** | **Expected Result** | **Actual Result** | **Test Results (Met/ Not)** |
| Are sensors collecting data | Check on the web application if the graphs are being plotted | the graph should plot in real time | The graph was plotting in real time | Met |
| Is micro-controller(NODE MCU)working | Check on the web application if the graphs are being plotted and if the actuators are also working | The graph should be plotting and the actuators should also be working | The graph is plotting and the actuators are also working | Met |
| Are the actuators working | The actuators should switch on/off based on the threshold set values vs the data from the micro controllers | The actuators should switch on/off based on the threshold values | The actuators did switch on and off based on the threshold values | Met |
| Is data being sent to the web server | Check if graphs are plotting in real time at the thinkspeak web server | Graphs should be plotting at the thinkspeak web server | The graph was plotting in real time at the server side | Met |
| Login at the web application | Try to login | The web application should be able to authenticate a user when logging in | The web app authenticated the user | Met |
| Is data being sent from the server to the web app | Check if graphs are plotting in real time on the Web application | graphs should be plotting in real time on the Web application | graphs are plotting in real time on the Web application | Met |
|  |  |  |  |  |

## Levels of testing and results

### 5.5.1. Unit testing

My system was submitted to assessments that focus on specific units or components of the software to determine whether each one is fully functional. The main aim of this unit is to determine whether the system is functioning as designed. This type of testing can be run each and every time a code is changed and also allows certain issues to be resolved as quickly as possible.

### Integration testing

This type of testing allowed me to combine all my units within my system as well as to find if they are any mishaps or defects within my system functions. This allowed me to know efficiently if my system is working or running. Different types of testing methods can be used, but the best and specific method to be used to get the system running will depend greatly on the way in which the units are defined.

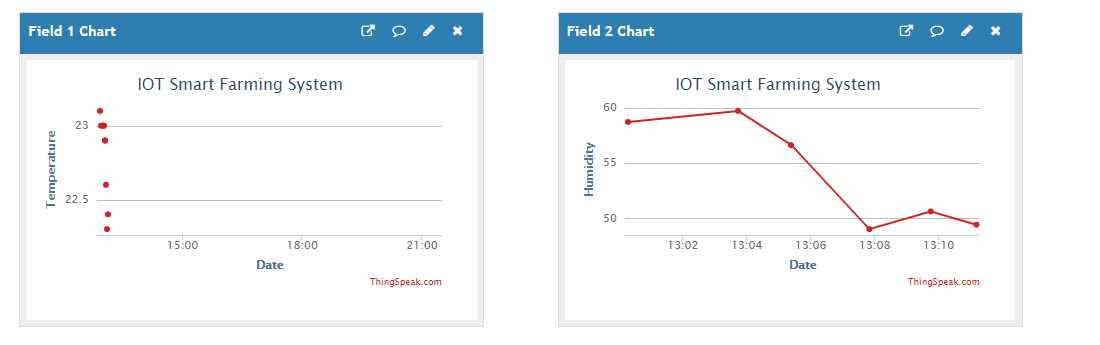
### Validation testing

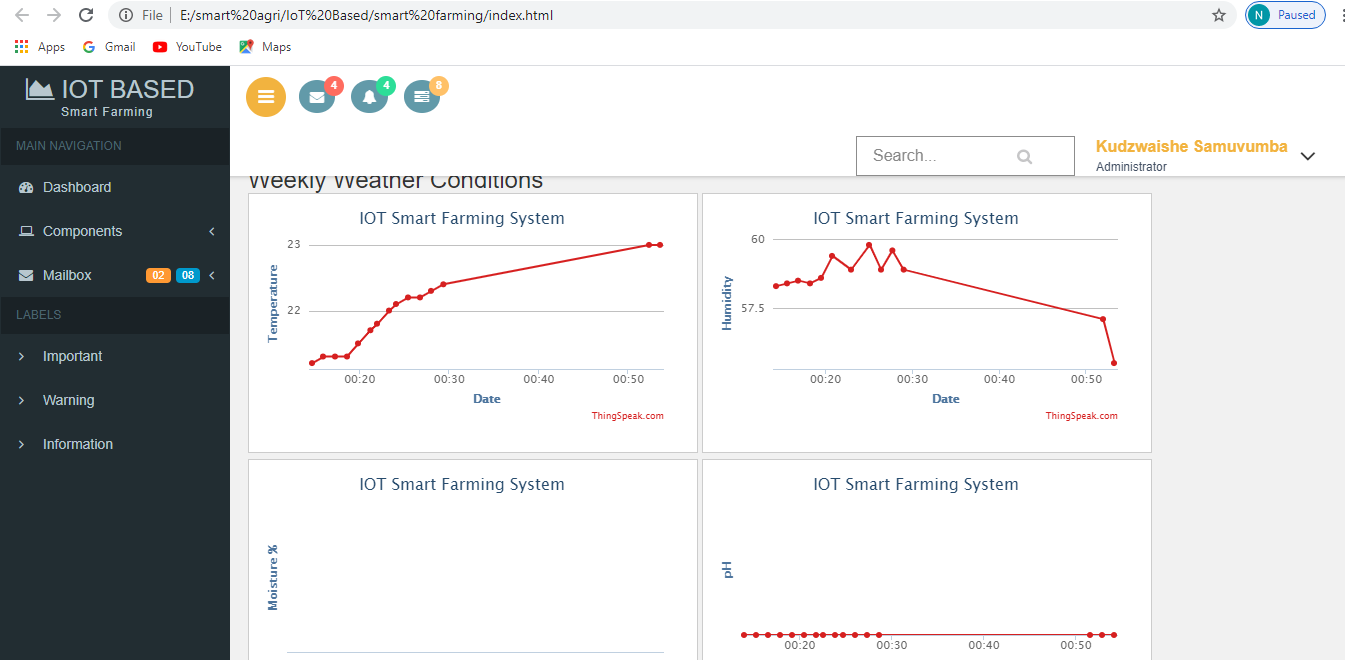
This testing is undertaken to make sure that the system meets the user requirements. It can also be done to show if the system is functioning as it should when subjected to an environment it was created to work in.

### System testing

Under this section we are testing the whole system as a whole having the goal to verify if the system was complied with all the necessary requirements and also meeting all the required standards of quality. This testing is performed in an environment that closely mirrors production. System Testing is very vital because it verifies that the application meets the technical, functional, and business requirements that were set by the customer

Below are the screenshots of the data sent to the web server (Thinkspeak) and the data sent to the web application





### Acceptance testing

This was done at the end of producing our system. It is done is ensure that the system is ready to be released. Under Software development life cycle, requirements can be modified and also misinterpreted as to what the customer would have specified. Under this phase a user can test to see if the system the doing what is supposed to do. With everything done then the system is ready to be delivered for production. In this case I Kudzwaishe Samuvumba I am the first user.

|  |  |  |
| --- | --- | --- |
| Parameters | Yes | No |
| Are sensors collecting data |  |  |
| Is micro-controller(NODE MCU)working |  |  |
| Are the actuators working |  |  |
| Is data being sent to the web server |  |  |
| Login at the web application |  |  |
| Is data being sent from the server to the web app |  |  |
| Is the web application user friendly |  |  |
| Is the System meeting the required security goals |  |  |
| Are the actuators turning on/off when the threshold value has been met |  |  |

## System evaluation

System evaluation is now determining a system’s merit, how worthy it is as well as its significance. This is done through using standards that are supposed to be followed.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | low | medium | high |
| Are sensors collecting data |  |  |  |
| Is micro-controller(NODE MCU)working |  |  |  |
| Are the actuators working |  |  |  |
| Is data being sent to the web server |  |  |  |
| Login at the web application |  |  |  |
| Is data being sent from the server to the web app |  |  |  |
| Is the web application user friendly |  |  |  |
| Is the System meeting the required security goals |  |  |  |

# 6. Chapter 6: Conclusion

## 6.1. Introduction

Smart farming is a management concept focused on providing the agricultural industry with the infrastructure to leverage advanced technology – including big data, the cloud, machine learning and the internet of things (IoT) – for tracking, monitoring, automating and analysing operations. Also known as precision farming, smart farming is software-managed and sensor-monitored.

## 6.2. Conclusion

This system will change the agricultural industry by saving resources, time, and labour it will also make farming smarter and more specific by delivering the correct conditions to specific plants 24/7 and over time it will improve farming because the better the conditions the more the harvest.

## 6.3. Scope of future work

In Future, IoT based smart farming can also become an Intelligent IoT based smart farming system in monitoring and predicting the soil condition for irrigating the field, machine learning techniques can be employed towards crop yield and crop disease prediction and also for deciding on spraying appropriate chemicals for proper growth of crop. Lastly the data security and integrity of agricultural data can be secured while transmitting for analysis towards prediction and sending the control signal for actuation.

## 6.4. References

# References

[1] Joaquín G, J. F. (2013). *“Automated Irrigation System Using a Wireless Sensor Network and GPRS Module.* IEEE Transactions On Instrumentation and Measurement.

[2] Kim Y., E. R. (2008). *“Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network,”.* vol.57, no.7, pp.1379-1387.

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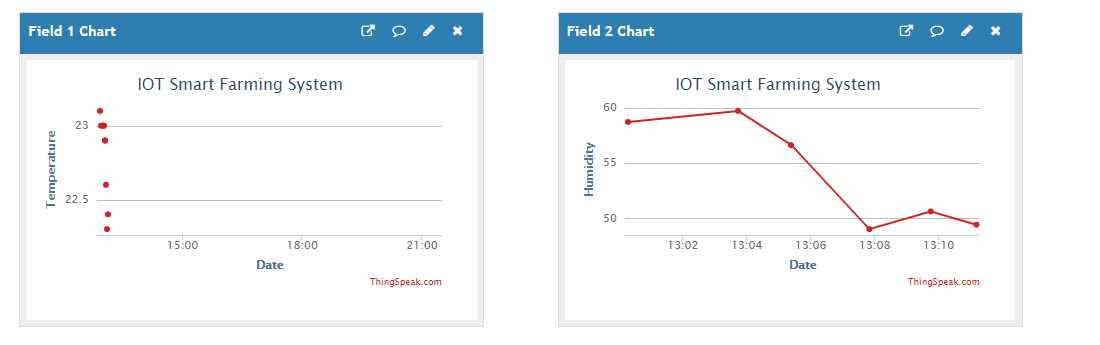
[9 ] Kim Y., Evans R.G. and Iversen W.M., “Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network,” Instrumentation and Measurement, IEEE Transactions on, vol.57, no.7, pp.1379-1387, July 2008. <http://dx.doi.org/10.1109/TIM.2008.917198>

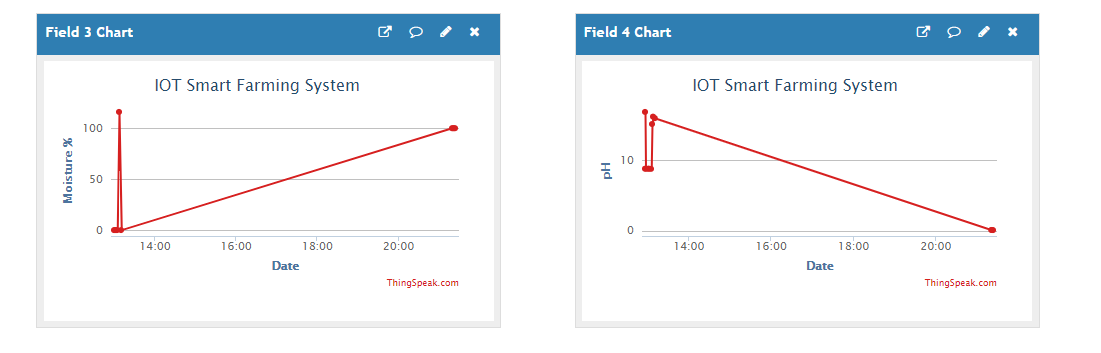
[10] Yang W., Liusheng H., Junmin W. and Hongli X., “Wireless Sensor Networks for Intensive Irrigated Agriculture,” Consumer Communications and Networking Conference, 2007. CCNC 2007. 4th IEEE, pp.197-201, Las Vegas, Nevada, Jan. 2007. http://dx.doi.org/10.1109/CCNC.2007.46

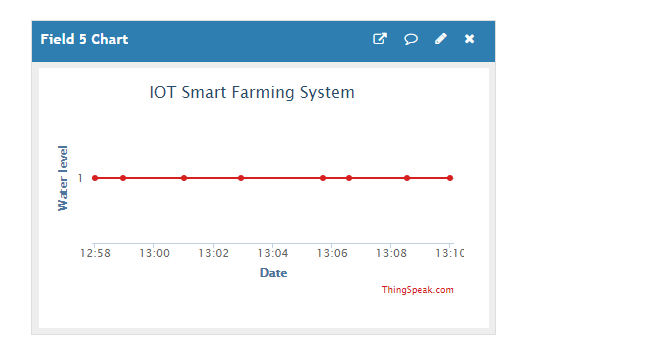
# 7. APPENDICES

## 7.1. Screen shots

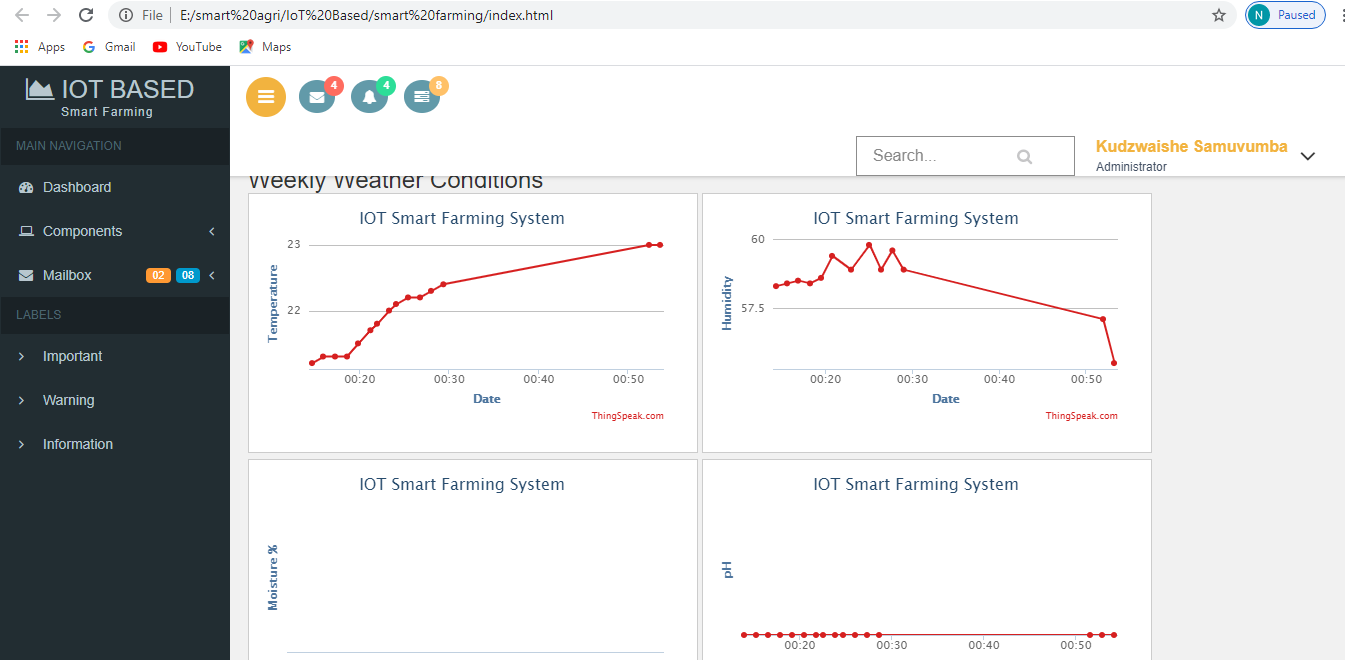
Screenshots from thinkspeak

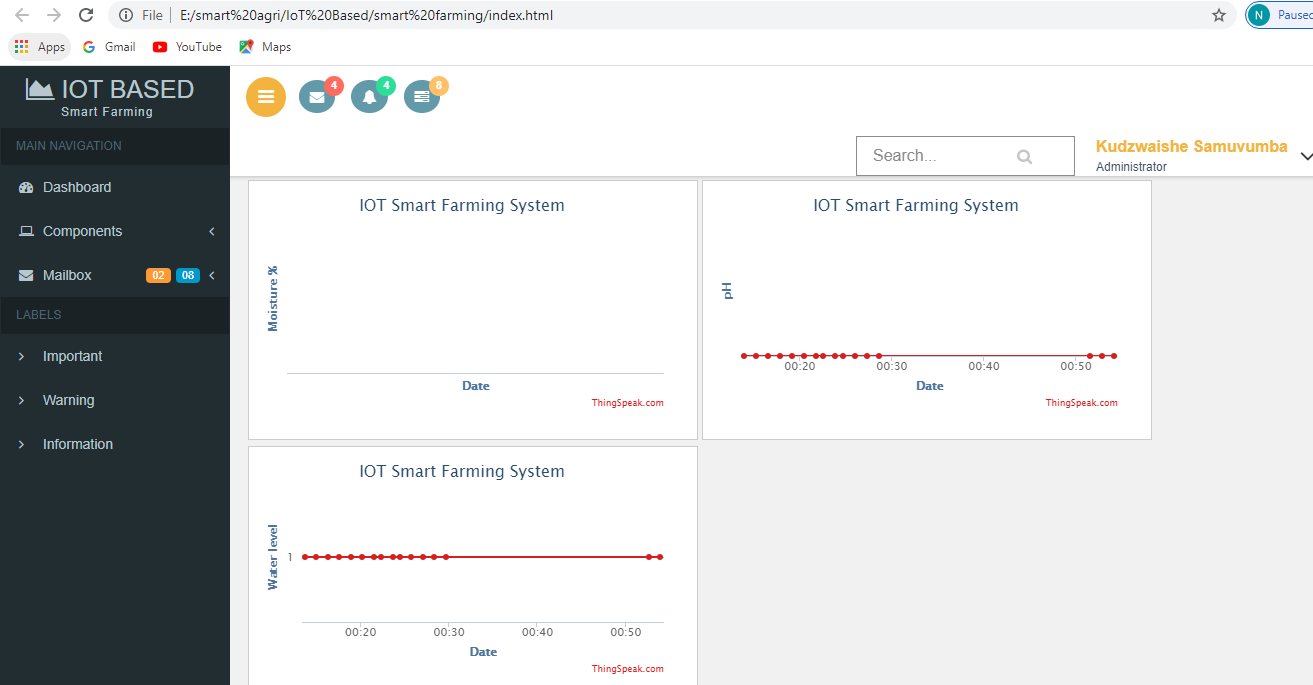






Screenshots from the Website





## 7.2. Sample code

**Arduino Code**

#include <ESP8266WiFi.h>;

#include <WiFiClient.h>;

#include <ThingSpeak.h>;

const char\* ssid = "BlitzTech\_Electronics"; //Your Network SSID

const char\* password = "0p3ns0urc3C0d3#12"; //Your Network Password

//#include "ESP8266WiFi.h"

#include "DHT.h"

#define DHTPIN D5 //where dht22 will be conected

#define DHTTYPE DHT22 //type of DHT sensor to be used

///////variables for storing data to be used

float b;

int buf[10],temp;

unsigned long int avgValue;

float phValue;

float pH;

float h;

float t;

int moisture;

int level;

int water;

DHT dht(DHTPIN, DHTTYPE);

//pin allocation for sensors and actuators

int pH\_sensor = A0;

int float\_switch = D3;

int pump = D7;

int buzzer = D2;

String server = "sipambi.000webhostapp.com";

WiFiClient client;

unsigned long myChannelNumber = 1084338; //Your Channel Number (Without Brackets)

const char \* myWriteAPIKey = "1ZCGPNXIG2KTXT47"; //Your Write API Key

void setup()

{

Serial.begin(9600);

WiFi.begin(ssid, password);

ThingSpeak.begin(client);

dht.begin();

pinMode(moisture, INPUT);

pinMode(D1, OUTPUT);

pinMode(float\_switch, INPUT);

pinMode(pump, OUTPUT);

pinMode(buzzer, OUTPUT);

digitalWrite(float\_switch, LOW);

}

void loop()

{

DHT\_vals();

ADC();

//send\_data();

}

void DHT\_vals()

{

delay(500);

h = dht.readHumidity();

t = dht.readTemperature();

Serial.print("Humidity: ");

Serial.print(h);

Serial.print(" %\t");

Serial.print("Temperature: ");

Serial.print(t);

delay(100);

ThingSpeak.writeField(myChannelNumber, 1,t, myWriteAPIKey);

delay(100);

ThingSpeak.writeField(myChannelNumber, 2,h, myWriteAPIKey);

delay(100);

}

void digital\_sensors()

{

level=digitalRead(float\_switch);

if(water<=50)

{

digitalWrite(pump, LOW);

Serial.println("pump high");

}

else if(water>=50)

{

digitalWrite(pump, HIGH);

Serial.println("pump low");

}

if(level==0)

{

digitalWrite(buzzer, HIGH);

Serial.println("Level low");

}

else if(level==1)

{

digitalWrite(buzzer, LOW);

Serial.println("Level high");

}

}

void pH\_measurement()

{

for(int i=0;i<10;i++) //Get 10 sample value from the sensor for smooth the value

{

buf[i]=analogRead(pH\_sensor);

delay(10);

}

for(int i=0;i<9;i++) //sort the analog from small to large

{

for(int j=i+1;j<10;j++)

{

if(buf[i]>buf[j])

{

temp=buf[i];

buf[i]=buf[j];

buf[j]=temp;

}

}

}

avgValue=0;

for(int i=2;i<8;i++) //take the average value of 6 center sample

avgValue+=buf[i];

phValue=(float)avgValue\*5.0/1024/6; //convert the analog into millivolt

phValue=3.5\*phValue; //convert the millivolt into pH value

Serial.print(" pH:");

Serial.print(phValue);

Serial.println(" ");

// digitalWrite(13, HIGH);

delay(800);

// digitalWrite(13, LOW);

ThingSpeak.writeField(myChannelNumber, 4,phValue, myWriteAPIKey);

delay(100);

}

void ADC()

{

digitalWrite(D1,HIGH);

pH\_measurement();

digitalWrite(D1,LOW);

moisture=analogRead(pH\_sensor);

water=map(moisture, 465, 1024, 100, 0);

Serial.println(moisture);

Serial.println(water);

delay(100);

ThingSpeak.writeField(myChannelNumber, 3,water, myWriteAPIKey);

digital\_sensors();

delay(100);

ThingSpeak.writeField(myChannelNumber, 5,level, myWriteAPIKey);

delay(1000);

}

void send\_data()

{

ThingSpeak.writeField(myChannelNumber, 4,pH, myWriteAPIKey);

}

**Web Application Code**

<!DOCTYPE HTML>

<html>

<head>

<title>IOT Based Smart Farming</title>

<meta name="viewport" content="width=device-width, initial-scale=1">

<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />

<meta name="keywords" content="Glance Design Dashboard Responsive web template, Bootstrap Web Templates, Flat Web Templates, Android Compatible web template,

SmartPhone Compatible web template, free WebDesigns for Nokia, Samsung, LG, SonyEricsson, Motorola web design" />

<script type="application/x-javascript"> addEventListener("load", function() { setTimeout(hideURLbar, 0); }, false); function hideURLbar(){ window.scrollTo(0,1); } </script>

<!-- Bootstrap Core CSS -->

<link href="css/bootstrap.css" rel='stylesheet' type='text/css' />

<!-- Custom CSS -->

<link href="css/style.css" rel='stylesheet' type='text/css' />

<!-- font-awesome icons CSS -->

<link href="css/font-awesome.css" rel="stylesheet">

<!-- //font-awesome icons CSS-->

<!-- side nav css file -->

<link href='css/SidebarNav.min.css' media='all' rel='stylesheet' type='text/css'/>

<!-- //side nav css file -->

<!-- js-->

<script src="js/jquery-1.11.1.min.js"></script>

<script src="js/modernizr.custom.js"></script>

<!--webfonts-->

<link href="//fonts.googleapis.com/css?family=PT+Sans:400,400i,700,700i&amp;subset=cyrillic,cyrillic-ext,latin-ext" rel="stylesheet">

<!--//webfonts-->

<!-- chart -->

<script src="js/Chart.js"></script>

<!-- //chart -->

<!-- Metis Menu -->

<script src="js/metisMenu.min.js"></script>

<script src="js/custom.js"></script>

<link href="css/custom.css" rel="stylesheet">

<!--//Metis Menu -->

<style>

#chartdiv {

width: 100%;

height: 295px;

}

</style>

<h3>Weekly Weather Conditions</h3>

</div>

<div>

<iframe width="450" height="260" style="border: 1px solid #cccccc;" src="https://thingspeak.com/channels/1084338/charts/1?bgcolor=%23ffffff&color=%23d62020&dynamic=true&results=60&type=line&update=15"></iframe>

<iframe width="450" height="260" style="border: 1px solid #cccccc;" src="https://thingspeak.com/channels/1084338/charts/2?bgcolor=%23ffffff&color=%23d62020&dynamic=true&results=60&type=line&update=15"></iframe>

<iframe width="450" height="260" style="border: 1px solid #cccccc;" src="https://thingspeak.com/channels/1084338/charts/3?bgcolor=%23ffffff&color=%23d62020&dynamic=true&results=60&type=line&update=15"></iframe>

<iframe width="450" height="260" style="border: 1px solid #cccccc;" src="https://thingspeak.com/channels/1084338/charts/4?bgcolor=%23ffffff&color=%23d62020&dynamic=true&results=60&type=line&update=15"></iframe>

<iframe width="450" height="260" style="border: 1px solid #cccccc;" src="https://thingspeak.com/channels/1084338/charts/5?bgcolor=%23ffffff&color=%23d62020&dynamic=true&results=60&type=line"></iframe>

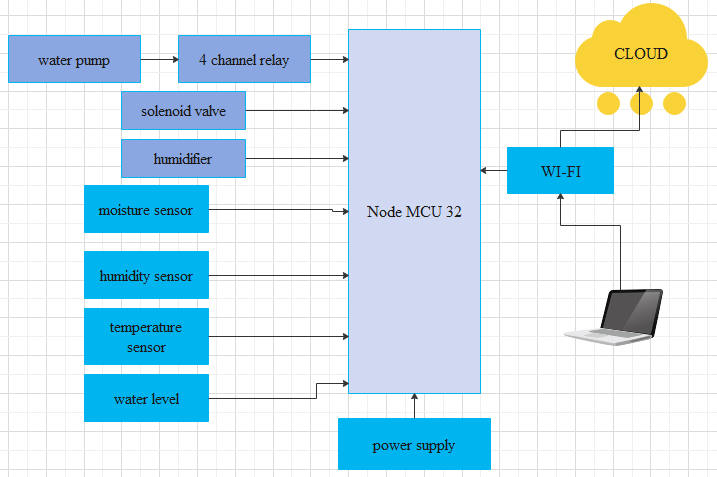
</div>

</div>

</div>

## 7.3. User manual

1. Make sure the sensors and actuators required are all connected well
2. Make sure that there is internet connection at the farming area
3. Make sure there is water supply and a water pump
4. The user should have a laptop with at least 1 gb Ram, 50 gb internal memory and it should be a windows 7 or better
5. The user should sign up on the iot smart farming web app
6. The user should be able to login with their credentials on the smart farming site
7. The user should be able to see their sensed data in the form of graphs on the web app



## Project Proposal

## Introduction

smart farming is a management concept focused on providing the agricultural industry with the infrastructure to leverage advanced technology – including big data, the cloud, machine learning and the internet of things (IoT) – for tracking, monitoring, automating and analysing operations. Also known as precision farming, smart farming is software-managed and sensor-monitored.

### Problem statement

* World population, as reported in June 2018, is a staggering 7.6 billion. It is estimated that this number will rise to 8.5 billion by 2030. With the rapid growth in world population, food consumption worldwide also grows rapidly. A rapid escalation in food production to cater to the growing demand is not an easy task.
* Without automation in the farming sector you cannot obtain data in real time which means they is no continuous monitoring and controlling of the chosen parameters
* Farmers couldn’t access information of their farm remotely
* Use of too much labour with low yielding results
* Using too much resources such as water, fertilizers, seeds and chemicals which lead to high cost and pollution

## Objectives

* Create an automated IOT based system which will be used in monitoring and controlling the crop field with the help of sensors Ph, humidity, temperature and soil moisture
* To create a web based application which enables the farmer to access data remotely in order to see what is happening on the farm
* To have a web server that stores the data from the sensors and sends the data in real-time to the web application

## Scope

The automated farms can yield more production of crops. The requirement of the atmosphere of the crop/plant can be fulﬁlled anywhere due to the controlled atmosphere. This can also make farming as a zero loss business.

## Literature Review

* + - 1. **AgriSys: A Smart and Ubiquitous Controlled Environment Agriculture System**

In [1], they proposed a smart Agriculture System (AgriSys) that can analyze an environment and intervene to maintain its adequacy. The system had an easy-to-upgrade bank of inference rules to control the agricultural environment. AgriSys mainly looked at inputs, such as, temperature, humidity, and pH. The system also could deal with desert-speciﬁc challenges, such as, dust, infertile sandy soil, constant wind, very low humidity, and the extreme variations in diurnal and seasonal temperatures. The system also provided increased productivity, enhanced safety, instant interventions, and an advanced life style. The system made was ubiquitous as it enables distant access.

* + - 1. **Design and Implementation of a Connected Farm for Smart Farming System**

In [2], they made a connected farm based on IoT systems for smart farming systems. They have used IoT to provide Internet connectivity for the sensors and controllers of the connected farm, they have deployed the Cube, a standardized device software platform for IoT devices. They also have used the Mobius, an IoT service platform (also oneM2M-compliant) that provides REST APIs with which the data collected from sensors (e.g., CO2 sensor)can be retrieved, but also the control commands can be sent to controllers (e.g., air conditioner). They had implemented a smart phone application that allows end users to remotely monitor and control their connected farm, e.g., turn on air conditioner by pushing a button on the smart phone.

* + - 1. **Smart Farming using Bluetooth wireless transmitter**

Research [3] been carried out by employing Bluetooth Wireless Transmitter that sense soil moisture, temperature etc and accordingly send the data to the Base station (BS) which makes the decision towards irrigation decision based on field and time. The irrigation control unit which is responsible towards irrigating the field pertaining to operating the sprinkler would receive the control signal from the BS. This is based on water Requirement of the fields. Some researchers are also working towards Variable rate Sensor based Irrigation System.

* + - 1. **An Automated field specific irrigation system**

Researchers Wall and King [4] developed an automated field specific irrigation system with soil moisture sensor and sprinkler valve controller. These systems do not take into consideration monitoring the water pollution in lakes or rivers and also do not consider M2M Communication concept. Research been carried out in developing an intensive sensor based irrigation monitoring system which is scalable and self organizing.

* + - 1. **Machine Learning in Agricultural Monitoring**

The machine learning algorithm has various uses in the field of agriculture monitoring which are being discussed here. In one of the research [5], Machine learning been applied towards Grape cultivation. In here farmers are unable to identify the disease manually on the grapes. The disease on grapes is identifiable only after the infection which takes lot of time and also has adverse effect on the vineyards. So accordingly a monitoring system developed for grape cultivation where temperature, relative humidity and leaf wetness sensors are deployed in the vineyard. The data collected at regular intervals are sent using Zigbee module to the server. The server here employs the hidden markov model algorithm towards training the data sets pertaining to Temperature, relative humidity and leaf wetness for analysing the data towards predicting the chance of disease on grapes before getting infected. This information is sent as alert message via sms to the farmer and expert. The system employs machine learning in early and accurate detection of disease in grapes and suggests pesticide to protect the crop from disease and reduce manual disease detection efforts. Also this system can be helpful for farmer’s towards giving information on schedule of fertilizer’s, pesticide spraying, irrigation etc which would help in improving the quality and quantity of grapes.

* + - 1. **Automated irrigation system (A2S)**

Research [6] also been carried out by developing an automated irrigation system (A2S) which is based on sensor network. Wireless sensors are being employed for monitoring and controlling the agricultural fields. The management sub system controls the sensor network and accordingly provides service to farmer’s by means of PDA. In this system, long distance communicated provided by means of WLAN between sensor network and server. Management subsystems consist of database, application and web server. Data from sensors are received by the application server which are stored in the database server. web server is accessed by farmer’s using PDA.

## Survey paper

IOT BASED SMART FARMING

Kudzwaishe Samuvumba,

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**Abstract**

**Agriculture has a major impact on economy of the country. A smart way of automating farming process can be called as Smart Farming. By implementing an automated system we can eliminate possible threats to the crops by reducing the human intervention. The major emphasize will be on providing favorable atmosphere for plants. These agricultural automated systems will help in managing and maintain safe environment especially the agricultural areas. Environment real time monitoring is an important factor in smart farming.**

**A web based user interface will be provided to control the hardware system and the system will be entirely isolated environment, equipped with sensors like temperature sensor, humidity sensor, photo emitter. The controllers will be managed by a master station which will communicate with the human interactive software. The system will provide smart interface to the farmers.**

**This smart system can increase the level of production than the current scenario. This system will realize smart solution for agriculture and eﬃciently solve the issues related to farmers. The environment will not be the barrier for production and growth of any plant and we can overcome the problem of scarcity of farming production.**

**Keywords: Smart farming, Embedded systems, Real time monitoring, Sensors.**

1. Introduction

From past years farmers face problems due to climate change or due to natural disasters like ﬂoods, famines, etc. It raises the topic of smart farming, precision farming or smart agriculture but the misconception about the smart farming is many people think that smart farming is about automated system which starts the motor pump and start the water ﬂow whereas some people consider that it just monitors the ﬁeld. But people have failed to notice that what if the system does all these things and try to take its own decision without much interaction with the user. The actual smart agriculture should monitor as well as take required decisions for the plant/crop.

I here have developed an IoT based Automated smart farming system where Moisture and Temperature sensor been deployed in the agriculture field towards capturing the data for watering the field. Now based on information gathered by the gateway unit from sensor, information sent to control unit which is NODE MCU. The NODE MCU based on the analysis of information extracted from the sensor for actuating the pump for watering the field, the humidifer for cooling the room and the alarm to alert the farmer that the water level is low. This information on data analyzed is recorded in Cloud server which allows the farmer’s to access from their web site. This shows a complete IoT based Automated smart farming system prototype developed whereby the actuators turn on or off based on the data gathered from the sensors which makes things simpler for farmer of not worrying about watering the field and checking the temperature, humidity and water level all the time. Also the famer’s can view the agricultural field watered or not from web server too.

2. Purpose

The aim of the project is to monitor and control the atmosphere of the farm with less human intervention. This smart system can increase the level of production than the current scenario. This system will realize smart solution for agriculture and efficiently solve the issues related to farmers. The environment will not be the barrier for production and growth of any plant and we can overcome the problem of scarcity of farming production.

3. Scope

The automated farms can yield more production of crops. The requirement of the atmosphere of the crop/plant can be fulﬁlled anywhere due to the controlled atmosphere. This can also make farming as a zero loss business.

**Proposed system**

The system proposed in this work uses an Node MCU 32 microcontroller and a collection of sensors of Ph, temperature, humidity, soil moisture and water level. The microcontroller periodically collects data from the sensors and sends it to the web server, and then updates the farmers website . The web server receives data from different devices and provides a web interface to the farmer as well as any expert. Whenever the sensor values drop below the threshold levels, the system automatically corrects them. For a given crop, the threshold levels of all environmental factors are decided. The system continuously monitors the field and whenever the water levels fall under the threshold level, it will switch ON the water supply and switches OFF when the water reaches a safe level.

I have developed an IoT based automated smart farming system where the temperature and moisture sensors deployed in field communicate to Node MCU 32 microcontroller. The sensed moisture, ph, humidity, water level and temperature values are then transmitted. The system here consists of three components. First component is the Node MCU 32 Microcontroller part where Soil Moisture, ph, water level, humidity and Temperature Sensor deployed in soil are connected to the Microcontroller which gives the moisture, ph, water level, humidity and temperature output based on soil condition, ph, water level, humidity and Temperature. The data received by Node MCU 32 are then sent to the web server. The predicted output is then used for sending the control signal via the serial communication to Node MCU for controlling water pump for watering the field accordingly the humidifer for cooling the room and the alarm to alert the farmer that the water level is low.. The last and final component is recording the soil moisture, ph, water level, humidity and Temperature level and prediction with date and time in the cloud server for farmer’s to access from their mobile or computer to have good knowledge and understanding on what’s happening in the field.

5. Conclusion

on the basis of literature survey and by analyzing the existing system, I have come to a conclusion that the proposed system will not only aid the farmers but will also help them to digitize their farming practice and in turn help them to yield the best from that soil without being dependent on the climatic conditions.

6. References

[1] Edordu C. and Sacks L., “Self Organizing Wireless Sensor Networks as a Land Management Tool in Developing Countries: A Preliminary Survey,” In Proceedings of the 2006 London Communications Symposium, September 2006, Communications Engineering Doctorate Centre, London, UK.

[2] Kim Y., Evans R.G. and Iversen W.M., “Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network,” Instrumentation and Measurement, IEEE Transactions on, vol.57, no.7, pp.1379-1387, July 2008. <http://dx.doi.org/10.1109/TIM.2008.917198>

[3] Joaquín G, Juan F , Alejandra N.G, and Miguel Ángel, “Automated Irrigation System Using a Wireless Sensor Network and GPRS Module”, IEEE Transactions On Instrumentation and Measurement, Vol.63, no.1, pp.166-176, 2013

[4] Karandeep K, “Machine Learning : Applications in Indian Agriculture”, International Journal of Advanced Research in Computer and Communication Engineering,

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## 7.6. Technical paper

IOT BASED SMART FARMIMG SYSTEM

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2 mugauri@gmail.com

*School of Information sciences, Harare Institute of Technology, Zimbabwe*

***Abstract- Agriculture has a major impact on economy of the country. A smart way of automating farming process can be called as Smart Farming. By implementing an automated system we can eliminate possible threats to the crops by reducing the human intervention. The major emphasize will be on providing favorable atmosphere for plants. These agricultural automated systems will help in managing and maintain safe environment especially the agricultural areas. Environment real time monitoring is an important factor in smart farming.***

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I here have developed an Intelligent IoT based Automated smart farming system where Moisture and Temperature sensor been deployed in the agriculture field towards capturing the data for watering the field. Now based on information gathered by the gateway unit from sensor, information sent to control unit which is NODE MCU. The NODE MCU based on the analysis of information extracted from the sensor for actuating the pump for watering the field, the humidifer for cooling the room and the alarm to alert the farmer that the water level is low. This information on data analyzed is recorded in Cloud server which allows the farmer’s to access from their web site. This shows a complete IoT based Automated smart farming system prototype developed whereby the actuators turn on or off based on the data gathered from the sensors which makes things simpler for farmer of not worrying about watering the field and checking the temperature, humidity and water level all the time. Also the famer’s can view the agricultural field watered or not from web server too.

1. Related Work

***AgriSys: A Smart and Ubiquitous Controlled Environment Agriculture System***

In [1], they proposed a smart Agriculture System (AgriSys) that can analyze an environment and intervene to maintain its adequacy. The system had an easy-to-upgrade bank of inference rules to control the agricultural environment. AgriSys mainly looked at inputs, such as, temperature, humidity, and pH. The system also could deal with desert-speciﬁc challenges, such as, dust, infertile sandy soil, constant wind, very low humidity, and the extreme variations in diurnal and seasonal temperatures. The system also provided increased productivity, enhanced safety, instant interventions, and an advanced life style. The system made was ubiquitous as it enables distant access.

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Researchers Wall and King [4] developed an automated field specific irrigation system with soil moisture sensor and sprinkler valve controller. These systems do not take into consideration monitoring the water pollution in lakes or rivers and also do not consider M2M Communication concept. Research been carried out in developing an intensive sensor based irrigation monitoring system which is scalable and self organizing.

***Machine Learning in Agricultural Monitoring***

The machine learning algorithm has various uses in the field of agriculture monitoring which are being discussed here. In one of the research [5], Machine learning been applied towards Grape cultivation. In here farmers are unable to identify the disease manually on the grapes. The disease on grapes is identifiable only after the infection which takes lot of time and also has adverse effect on the vineyards. So accordingly a monitoring system developed for grape cultivation where temperature, relative humidity and leaf wetness sensors are deployed in the vineyard. The data collected at regular intervals are sent using Zigbee module to the server. The server here employs the hidden markov model algorithm towards training the data sets pertaining to Temperature, relative humidity and leaf wetness for analysing the data towards predicting the chance of disease on grapes before getting infected. This information is sent as alert message via sms to the farmer and expert. The system employs machine learning in early and accurate detection of disease in grapes and suggests pesticide to protect the crop from disease and reduce manual disease detection efforts. Also this system can be helpful for farmer’s towards giving information on schedule of fertilizer’s, pesticide spraying, irrigation etc which would help in improving the quality and quantity of grapes.

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Research [6] also been carried out by developing an automated irrigation system (A2S) which is based on sensor network. Wireless sensors are being employed for monitoring and controlling the agricultural fields. The management sub system controls the sensor network and accordingly provides service to farmer’s by means of PDA. In this system, long distance communicated provided by means of WLAN between sensor network and server. Management subsystems consist of database, application and web server. Data from sensors are received by the application server which are stored in the database server. Web server is accessed by farmer’s using PDA.

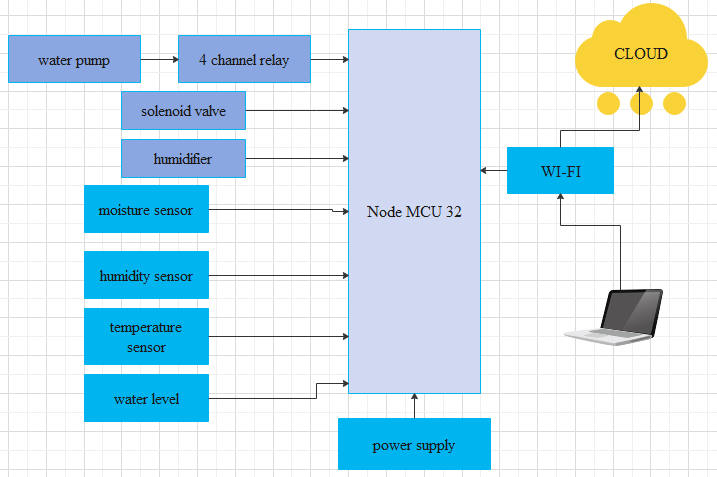
4.7

***Proposed system***

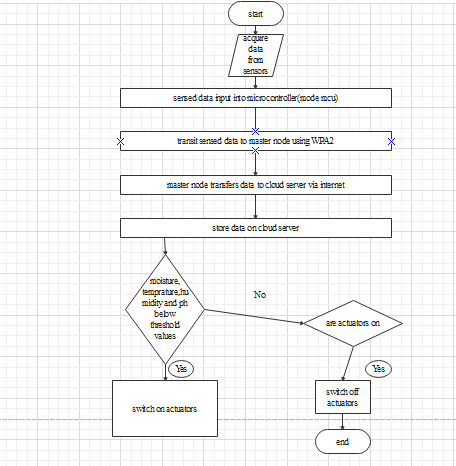
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1. *Solution Architecture*



1. *Flowchart*



1. *Implementation*

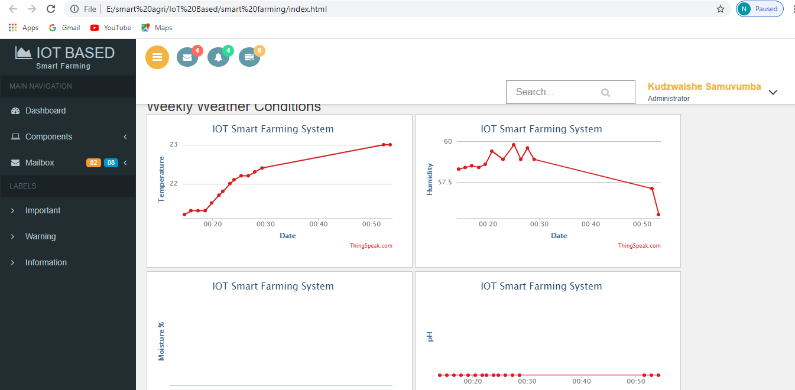
The system proposed in this work uses an Node MCU 32 microcontroller and a collection of sensors of Ph, temperature, humidity, soil moisture and water level. The microcontroller periodically collects data from the sensors and sends it to the web server, and then updates the farmers website . The web server receives data from different devices and provides a web interface to the farmer as well as any expert. Whenever the sensor values drop below the threshold levels, the system automatically corrects them. For a given crop, the threshold levels of all environmental factors are decided. The system continuously monitors the field and whenever the water levels fall under the threshold level, it will switch ON the water supply and switches OFF when the water reaches a safe level.

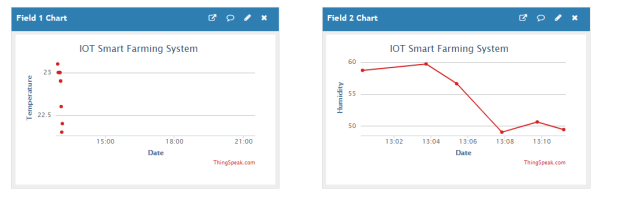
1. *Coding*

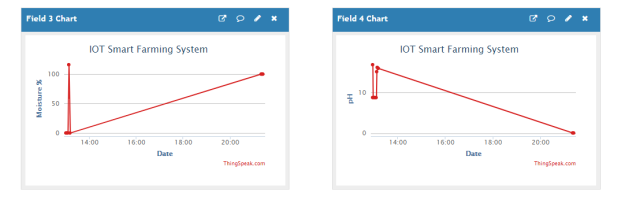
I used Arduino IDE to set the threshold values of the system and to link the hardware to the software and also to define my parameters.

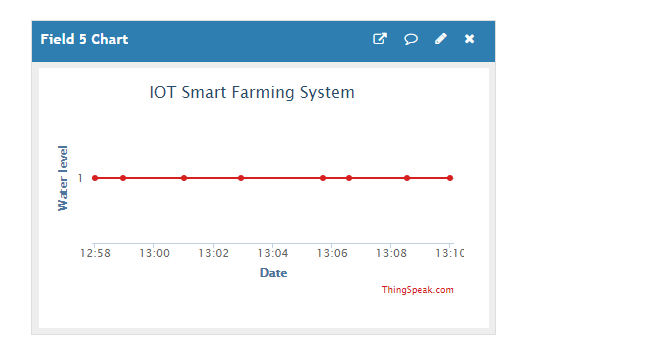
1. *Discussion*

The proposed system will not only aid the farmers but will also help them to digitize their farming practice and in turn help them to yield the best from that soil without being dependent on the climatic conditions.









1. *Conclusion and Future Work*

Therefore, the paper proposes a thought of consolidating the most recent innovation into the Zimbabwean farming system to turn the customary techniques for water system to current strategies in this way making simple profitable and temperate trimming. Some degree of mechanization is presented empowering the idea of observing the field and the product conditions inside some long-separate extents utilizing cloud administrations. This idea of modernization of farming is straightforward, reasonable and operable. As relying upon these parameter esteems rancher can without much of a stretch choose which fungicides and pesticides are utilized for enhancing crop creation. In Future, IoT based smart farming can also become an Intelligent IoT based smart farming system in monitoring and predicting the soil condition for irrigating the field, machine learning techniques can be employed towards crop yield and crop disease prediction and also for deciding on spraying appropriate chemicals for proper growth of crop. Lastly the data security and integrity of agricultural data can be secured while transmitting for analysis towards prediction and sending the control signal for actuation.

*Acknowledgements*

I would like to extend my heartfelt gratitude to my supervisor Mr. Mugauri for the support and guidance. Without his constant and timely advice and assistance, it would have been impossible to finish this project. I appreciate all the feedback, support, unwavering patience and motivation from him. I would also like to thank the participants that took part in my observational study. Without your participation, this dissertation would be incomplete.

I want to thank my parents Mr and Mrs Samuvumba for the financial support that has enabled me to complete my project without any lack. It has been a smooth sail and am forever indebted to you for all the support you have provided me.

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