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Thesis Title:

WATER USAGE PREDICTION USING AUTOMATED HOME GARDEN WATERING SYSTEM.

A dissertation submitted in partial fulfilment of the requirements for the award of the degree of M.Sc. in Internet of Things/Wireless Intelligent Sensor Networking.

Submitted by: MUGOREWERA Evelyne

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December 2022

DECLARATION

I hereby declare that this Dissertation contains my own work except where specifically acknowledged.

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CERTIFICATE

This is to certify that the project entitled" **Water Usage Prediction Using Automated Home Garden Watering System**" is a record of original work done by **MUGOREWERA Evelyne** with Reg number: **219015302** in partial fulfilment of the requirement for the award of masters of sciences in Internet of Things in College of Science and Technology, University of Rwanda, academic year 2019-2020.

This work has been conducted under the guidance of Dr. Christine NIYIZAMWIYITIRA and Dr. Richard MUSABE.

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ABSTRACT

The automatic systems are more chosen than manual system. Smart watering system in garden is the combination of several hardware equipment and software applications that trigger the water usage with respect to the given threshold. This IoT system maintains proper usage of water used in home garden watering system. The threshold is set based on humidity, temperature and moisture of soil parameters inputs from the soil and around the garden area. The collected data are stored, analysed and modelled using machine learning algorithms to make prediction of water consumption throughout a period of two weeks, therefore informing water suppliers about the amount of water that shall be produced in the future. To make this system more intelligent, machine learning data trains to be conducted on the system by the use of data sensed in different periods of the two weeks from Meteo Rwanda , the consideration of garden watering timetables and schedules to be considered too.

Keywords: water supply prediction, IoT, Artificial Neural Networks, Machine learning.

LIST OF SYMBOLS LIST OF ACRONYMS

ADC: Analog to Digital Convertor.

AL: artificial Intelligent

ANN: artificial neuron network

API: Application programming Interface.

DHT: Digital temperature and Humidity sensor

GND: Ground

ICT: Information and communication technology

IoT: Internet of Things

JDK: Java Development Kit

JRE: Java Runtime Environment

KNN: K-nearest neighbour

LED: Light emitting diode.

M2M: Machine to Machine

MATLAB: Matrix Laboratory

NODE MCU: Combines Node and Micro controller Units

NTC: Negative Temperature Coefficient

PDA: Personal Digital Assistant

PHP: Hypertext Preprocessor

RBFN: Radial basic function network

RES: Renewable Energy sources

VCC: Voltage collector to collector

Wi-Fi: Wireless fidelity

XAMPP: Apache, MySQL, PHP and Perl

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CHAPTER ONE. INTRODUCTION

1.1 Background

Plant life are vital part of life. Kigali city is one of the olive green capitals in Africa and green nation strategies are set in place for the over-all working of Rwandans to deliberate go-green goal therefore making green grounds at homes is an essential techniques to realise the goals of the country[1]

Inappropriately, **water shortage** make us fail to attain the aim of Kigali city. This project aimed at a smart irrigating scheme by the usage of IoT composed by smart technologies is captivating into consideration to use it efficiently at Kigali town[2]. The scheme helps to classify garden-related data therefore the amount of water desirable for irrigating the plot is determined in the forthcoming use where there are comparison of imported data of the data collected by sensor node and those data from Meteo Rwanda whereas existing smart garden watering systems were using watering the water in the garden without notification of amount of water needed[3].

Rwanda Meteorology agency is used to observe, analyse and predict the weather forecast where weather forecast is used to analyse the state of the weather in an area with an assessment of likely developments[4].

Figure 1 Jaria Garden Kabuga site

Figure 2 Different types of flowers in gardens

Figure I shows different types of flowers in the garden that needs different soil moisture and temperature. These are Palms, Yellow loosestrife, Zinnia, Wild senna, summer savory

The system is getting information from the Jalia garden where data are monitored and recorded from the deployment of sensors in the Garden depending on physical conditions to the environment, these measurements are Temperature, humidity and Soil wetness and organising the collected numbers to the central locations and save these data to remote MYSQL server.

Meteorological Rwanda is used to collect data from the weather forecasting and be accessed from Cloud /thingspeak, and the purpose of weather forecasting is to predict the future state of the weather at given location so the user can plan their activities accordingly.

Artificial Neuron Network (ANN) is one of the only techniques currently available for training machines to truly think like people and it is a tool used within the deep learning space in this case is used to predict the amount of water wanted in the Garden.

Artificial Neural Networks (ANN) are an unusual type of engine learning procedures that are modelled after the humanoid mind. It works similar in what way the neurons cutting-edge our nervous scheme are talented to study from the historical records, similarly the ANN is capable to study from the statistics and deliver answers in the form of forecasts or arrangements[5].It's used to study after the samples of the facts sets, accomplished of captivating example facts slightly than the whole dataset to deliver the yield results.

There are different structure of ANN and which are, Input layer, hidden layer and output layer. In Input layer is where ANN receives contribution info in the procedure of several scripts, figures and images, the hidden layer look after numerous kinds of accurate calculation on the contribution facts and know the designs that are part the production layer gain the result that gained through severe calculations done by the hidden layer. The general initiation tasks used in Artificial Neural Networks are Sigmoid, RELU, Softmax, tanh[5]

In ANN the multiple parameters that disturb the act of the perfect. The yield of ANNs is typically reliant on these limits. Some of these limits are masses, preferences, learning rate, consignment size.

ANN has two types which are 1) Feedforward Neural network and 2) Feedback Neural network where Feedforwrd ANN, the movement of info is captivating place in one way typically used in oversaw knowledge for examples such as ordering image respect while Feedback ANN is used in loops largely for recall retaining such as in the case of recurring neural nets. These kinds of nets stand greatest suitable on behalf of parts wherever the facts is consecutive or time-dependent.

Here are numerous schemes that consume made it likely to enhance watering managing, after the usage of drop watering schemes to regulate shortfall watering plans talented to uphold produces by minor watering capacities. Info and communication technologies (ICT) consume donated to the maintainable managing of water usage in Garden[6].

The placement of wireless device nets in garden by Internet of Things (IoT) skills and the distant management of facts with cloud calculating consume allowable huge monitoring of undeveloped variables, which produce a huge amount of info regarding the garden[7].

The MATLAB is used to train a neural network to predict time series based on sensor data stored in the Database/Dashboard where the data are tested, validates and trains to predict the real amount of water needed in the in garden.

This information helps the owner of the garden to control the water place of the soil besides weather to sort choices around watering then whether dissimilar shortfall watering plans modified to series and lifetime of the garden must be applied.

Thereafter data was sent to the cloud to be stored and then can be accessed by user interface, where it gives notifications to the water supplier, owner of the garden by informing them that

the garden is having threshold which is high or low in order to release water according to the collected information.

By this scheme, individuals can consume an improved controller on the amount of water supposed to be watering and can also save time. The system is built upon an automatic watering scheme algorithms by means of mostly a soil wetness sensor to get daily amount of water to be supplied in the garden by the use of Android smart phone.

1.2 Motivation

As Jalia Garden is still growing, there is much need of source of funds, one way is good management of the properties it is already possesses, having an intelligent prediction of water usage system will decrease water consumption in general, and the finance put in paying water usage will be put in other resources for the development of the garden to go forward.

1.3 Problem Statement

Previous researchers showed weight monitoring systems and different inducements towards water management are introduced, through working out the facts set for forecasting the soil disorder near the irrigating of the garden[8] by designing and implementing Smart IoT founded Automatic Irrigation scheme, however they seem non-intrusive as they do not show how on the way to forecast the amount of water needed in field for the upcoming use. Literature review misses a complete algorithm which can work with existing buildings to predict amount of water usage, by empower users to know and access of water usage, on real-time and accurate basis.

In home gardens the major problem which owner of garden lack is the water shortage, therefore to recover this water scarcity, there are need for prediction of water usage in the garden which is used for specific time, by using the thresholds of existing system which was implemented in order to prevent water scarcity also most of the watering of garden are done manually by human intervention.

The general focus on this research is to build prediction of water usage system which is intelligent to work on both supervised and unsupervised manner. Obtaining an answer for this question will minimize problems that arise from water misuse and the general work of technicians will be minimized. With the number of problems raising from water distribution and management in the gardens “uncontrolled and unreliable water consumption comes first

as it is the main cause of huge price spent, hoping that finding a solution for it will save the corresponding government money in the area.

Basing on data provided by Jalia Manager, the services and functions that consume high water includes watering of the Garden which takes 100m2 per month, where some of them takes long time of watering instead of doing other work, hence hereby wondering how to reduce water usage and water bill, some ordinary solutions enabled users to use manually and estimating the time for watering but cannot solve the problem of management of water usage.

The over-all impartial of this investigation remains to design plus implement prediction for water usage System with fully automated IoT intelligent, a solution which will boost the optimization, efficiency and reliability in water consumption and its management through making the existing system of watering by integration of sensors, actuators and communication modules

1.4 Study Aims

1.4.1 General Objective

The over-all impartial of this investigation is design then implement prediction for water usage System with fully automated IoT intelligent, a solution which will improve the efficiency and reliability of water consumption and its management through making the existing system of watering by integration of sensors, actuators and communication modules to reduce time and human interventions during watering activities

1.4.2 Specific Objectives.

- Literature reviewing, the existing solutions, the working of the available water consumes the time and
- Design and implement automated home garden watering system by comparing the results with the ordinary ones to prove the difference and effectiveness of the solution.
- Predicting water usage in the garden

1.5 Hypothesis

This complemented research system helps Jalia Garden to have full control over all Garden to other machinery. Water usage will be minimized as the current system was enhanced with intelligence to work in both supervised and unsupervised manners. The output of the prediction

of water usage was updated on the system dashboard created with XAMMP-cross platform. Moreover, the overall amount of water spent by the Garden management team are being minimized to reduce water usage, time and human intervention in watering activities. Where the system is using different parameters that collected data from sensor node by comparing them to those data of Meteo Rwanda and get real data for the future use.

2. ANN can be used to predict water usage through automatic home system by the use MatLAb

1.6 Study Scope

This project covered about 1.6 hectares(65*83) garden which is located at Gasabo, Rusororo sector, Nyagahinga cell and Kabutare Village along the road from the Rusororo sector and near Rusororo Adventist church and is flat area[9]. For water usage prediction, using automated home garden watering system data fetched during rainy season and sunny season with in two weeks so basing on the data fetched in these period, the prediction and foretell be easy.

1.7. Significance of the Study.

The deployment of intelligent water management system based on IoT, is contributed and benefit in assisting and promote the minimization of water usage starting from the available water of WAS AC and sanitation of infrastructure. With the deployment of Machine Learning artificial Neural Network System, water usage management become easier to be done in efficient manner which is used to reduce the water usage in residential and gardens of Kigali city and financially.

It saves water bills and time spent during watering of garden and thus generally help in the management of water.

1.8. Institution of the Learning

This investigation is complete of six episodes. The major episode is an overview collected through contextual, incentive, problematic report, study aims, hypotheses, study choice, meaning of the training and organization of the study as well as deduction. Another episode emphases arranged current works through presenting the gaps and how to fill the holes. The third unit summaries the means working in the operation of the project. It clues to strong operation idea. The quarter episode is the investigation and strategy this chapter shows the prototype, corresponding data dashboard & serial monitor and how the installation of sensor nodes is done. The fifth episode clarifies the outcomes of the system and lastly the last section accomplishes the deliberations and delivers references.

Appendix: this scripts containing the overall codes for the Arduino based prototype showing how the Artificial Neural Network was applied with the corresponding libraries' calling **p**rocess. It shows the time how the project was be implemented. Briefly this first chapter defines the problems and the guidelines for the implementation.

CHAPTER TWO: LITERATURE REVIEW

Different researchers wrote about smart irrigation, the use of sensors and solenoid actuators to monitor and control soil quality in gardens, but did not talk about the water usage prediction which is used to inform the amount of water needed, the climate keeps on changing, the water utilities keeps changing the water usage policies, therefore it was of an interest to conduct a research leading to prediction of exact amount of water to splay in gardens basing on the data sensed from soil moisture and temperature & humidity sensors.

2.1 RELATED WORKS

April 2019, Pratima Bagmare et Al worked on the automated home gardening system was designed by using NODE MCU and sensors to protect the garden plants for overwatering and predict the sunlight periods[10].

December 2019, Raju Anitha, et al. Talked about Internet of Things Founded Involuntary Soil Wetness Observing Scheme using Raspberry PI where they developed scheme that aid a agriculturalist to recognise his ground standing in his home-based or he might be exist in some portion of the ecosphere[11].

June 2019 F. Adenugba S. Misra et Al. **describes about** "Smart watering scheme for ecological avoidance of depletion in Africa "where Smart watering schemes motorised by ability to vigour bases take remained established to considerably recover by harvest produce and the effectiveness of cultivation formerly the composed data is second-hand to forecast setting situations by means of the Radial Basis Function Network (RBFN)[12].

June 2019 Kirtan Jha a et Al. talked about "Artificial Intelligence in Agriculture "It discusses around dissimilar mechanisation put into practise like IoT, Wireless Infrastructures, Machine learning and Artificial Intellect, Deep learning where different problems concerning agriculture can be solved[13]

September 2018 ,Kirtan Jha1 , et Al, described about " Intellectual watering scheme by means of Robotics and predictive analytics ", This daily proposes the theme of False intellect, knowledge engineering and entrenched scheme, In additional deliberates the amalgamation of AI and entrenched knowledge in the cultivation subdivision but they were motionless problem of water management[14]

March 2018, Ramkumar.E, et al. Described the automation in plants and crops monitoring in gardens using IoT and the integration of the Raspberry Pi and its different models and continuously monitors the conditions of the garden and notifies the user to make the changes that require immediate action for the garden[15]

June 2018, T.Thamaraimanalan1, et al. described smart garden monitoring system using IoT where they use Node MCU, sensors and firebase to uphold the wildlife of the florae by unceasingly checking the strictures foremost to the augmented lifetime for together florae and humanoid existences[16].

July 2018 Basim H. Khudair a et al talks about False Neural System Perfect aimed at the Forecast of Groundwater Excellence, Through the goal of more decisive WQI, four aquatic limits such as (i) pH, (ii) Chloride (Cl), (iii) Sulfate (SO4), and (iv) Total melted objects (TMO), remained occupied into deliberation but there was no prediction of water usage[17]

July 2017, Sandhya.B.R1 et al., described the system of home automation gardening by use of Raspberry pi3 and sensors where the scheme was talented to inform the operator that the aquatic lack rises in the chief aquatic source and operator can likewise interconnect by the scheme through distribution of SMS or email [18]

2016, Kizito Masabo, et al. Described of how to design and Implement the Smart watering scheme aimed at Better Water-Energy Competence by use of sensors, embedded system and Bluetooth where water was expected to thirsty positions of the ground[19].

September 2017, A.Susmitha, T.Alakananda et al , talked about, **"**Automatic watering Scheme by means of Climate Forecast for Well-organized Practise of Aquatic Capitals" where they used drip irrigation to recover the practice of aquatic [20]**.**

December 2017 Yuthika Shekhar, et al , talked about "Brainy IoT Founded Automatic watering scheme " wherever the system consume industrialised an Brainy IoT founded Mechanical watering scheme wherever instrument statistics relating to dust dampness and high

high temperature taken accordingly to KNN (K- Nearest Neighbor) ordering algorithm for analysing the instrument statistics for forecast to watering the dust by aquatic[8]

May 2020 Marion Olubunmi Adebiyi, et al, describes about how Farmland optimisation and crop monitoring system can be predicted, where they used numerous contributions by way of soil type, type of crops soil PH they used random forest algorithms to analyse and categorise datasets of the yield topographies by generating subset founded on chance yield article limits[21]

June 2017 Agus Siswoyo et al, talks about the Request of false neural network in modelling way of wheelchairs by means of neurosky mind set of moveable expedient where they have predicted the way of electronic wheelchair using intelligence sign contribution for bodily flexibility damage[22]

First author talked about the automated garden watering by preventing overwatering but this project deals with prediction of water usage in the future,

Second describes how system helps farmer to know his field status but they don't talk about the water needed by the farmer for the future use.

Furthermore, many authors talked about the prediction of environmental conditions by use of Radial Basis Function Network, others they use drip irrigation to improve the usage of water and use of KNN (K-Nearest Neighbour) to classify the soil and water needed, but they don't talk about the water needed by the garden for the future by comparing the past data collected, present data to predict what amount of water needed in future use.

2.2 Definition of Terms

In this work there are technical terms that should be explained more. Those are NodeMcu v3 ESP8266, IOT, ThingSpeak, temperature and humidity sensor, soil moisture sensor, artificial neural Network.

2.2.1. NodeMCU

NodeMCU is an open-source founded microcode and growth panel particularly embattled for IoT founded Requests. It comprises bios that turns on the ESP8266 Wi-Fi SoC from Espressif Schemes and hardware which is founded on the ESP-12 unit.

Around NodeMCU ESP8266

The NodeMCU ESP8266 growth panel derives by the ESP-12E unit covering ESP8266 mark taking Tensilica Xtensa 32-bit LX106 RISC microchip. This microchip ropes RTOS then functions at 80MHz to 160 MHz adaptable timepiece incidence. NodeMCU consumes 128 KB RAM and 4MB of Flash memory to stock statistics and agendas. Its tall dispensation control by innate Wi-Fi / Bluetooth and Deep Slumber Working topographies brand it perfect for IoT schemes[23].

NodeMCU container be motorised by Micro USB jack and VIN pin (External Supply Pin). It ropes UART, SPI, and I2C border.

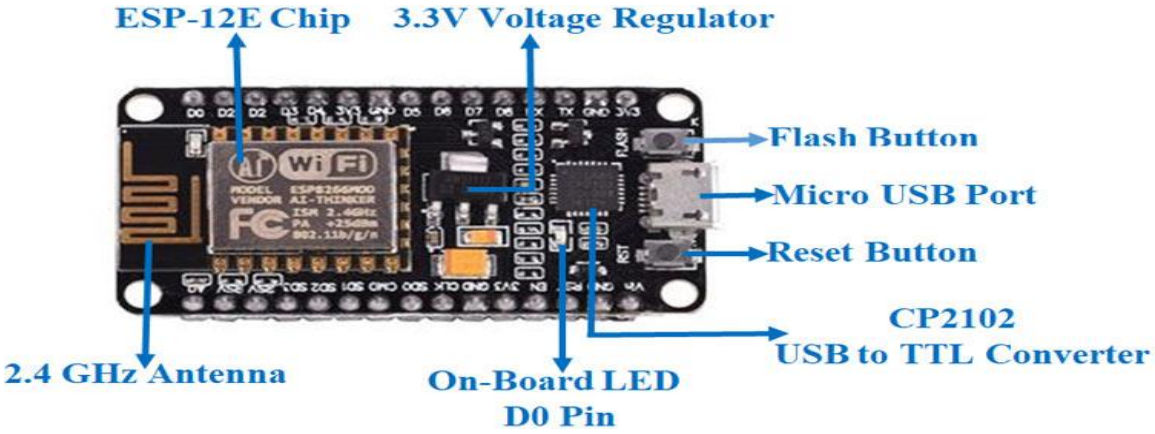


Figure 3 NodeMCU

Program design NodeMCU ESP8266 by Arduino IDE

The NodeMCU Growth Panel can be effortlessly automatic by Arduino IDE subsequently it is informal to usage.

User interface design NodeMCU by the Arduino IDE willpower barely take 5-10 notes. Altogether essential is the Arduino IDE, a USB chain and the NodeMCU panel itself. Container chequered this Receiving On-going Discussion group for NodeMCU to make Arduino IDE for NodeMCU.

Uploading principal database

When Arduino IDE is connected on the processer, attach the panel by the processer with the USB chain. Currently exposed the Arduino IDE and select the precise panel by choosing Tools>Boards>NodeMCU1.0 (ESP-12E Module), then select the precise Harbour via selection Tools>Port. To grow it on-going by the NodeMCU panel and wink the integral LED, weight for instance cypher by choosing Files>Examples>Basics>Wink. When the instance cypher is laden into IDE, clack on the 'upload' key assumed on the upper bar. When the upload is over, must understand the integral LED of the panel blinking.

Requests of NodeMCU

Prototyping of IoT plans

Little control battery-operated requests

System schemes

Schemes needful manifold I/O borders by Wi-Fi and Bluetooth functionalities

2.2.2. DHT11 device.

DHT11 instrument events and delivers moisture and hotness standards successively ended a only cable. It container amount the comparative moisture in proportion (20 to 90% RH) then hotness in degree Celsius in the variety of 0 to 50°C. It consumes 4 pins, single of which is second-hand for statistics message in sequential method. It has operating voltage of 3.3v to 5.3v, functioning present of 0.3mA (gaging) 60uA (reserve) and accuracy of+-1c0 and +-1%.

The DHT11 is a usually rummage-sale Hotness and moisture sensor. The sensor originates by a devoted NTC to quantity hotness then an 8-bit microcontroller to production the standards of hotness and moisture as sequential statistics. The instrument is too sweatshop consistent then henceforth informal to border by additional microcontrollers[24].

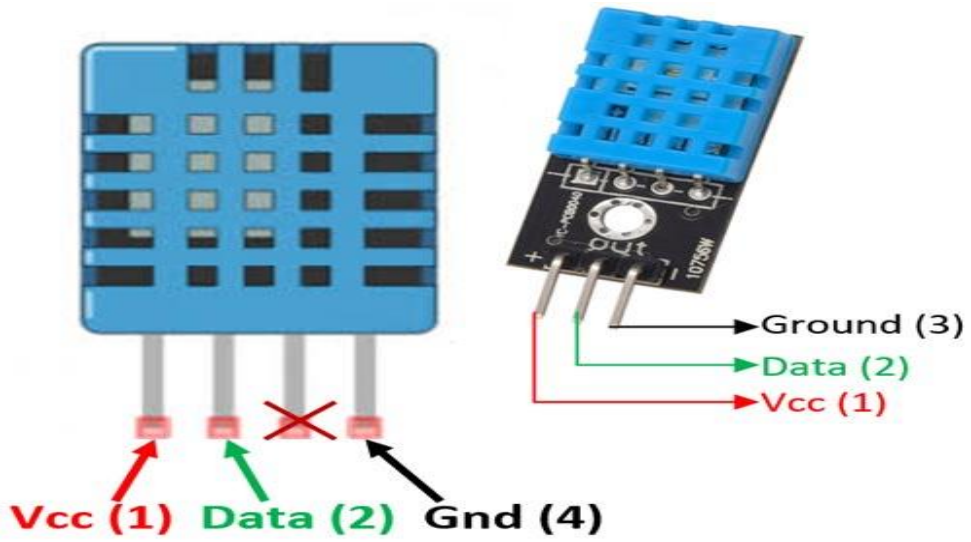


Figure 4 DHT11 sensor

2.2.3. Soil moisture sensor

Soil moisture is essentially the gratified of aquatic current in dust. This can be slow by a dust moistness sensor which contains of binary showing investigations that perform as a investigation. It can amount the moistness gratified in the dust founded on the alteration in confrontation among the two showing dishes[25].

The output of the dust moistness sensor variations in the change of ADC standards as of 0 to 1023. NodeMCU ADC container be rummage-sale to amount analog voltage as of the soil moistness sensor. Attach the binary tittles of the moistness sensor to the binary tittles on the Loudspeaker tour by hurdler chains. Attach the Vcc as of the Loudspeaker to the 3.3V pin on the NodeMCU. Attach the GND pin to the ground (GND) pin on the NodeMCU. Attach the Analogy pin to the A0 pin on the NodeMCU. The moistness of the soil theatres a vital part in the watering arena as well as in commons for florae. As nutrients in the soil deliver the food to the florae for their growing. Providing aquatic to the florae is also vital to modification the hotness of the florae. The hotness of the vegetable can be altered with aquatic by means of the technique similar transpiration. Then vegetable origin schemes are too industrialised healthier once increasing inside humid dust. Life-threatening soil moistness heights can leader to anaerobic circumstances that can inspire the vegetable's development as healthy as dust pathogens[26]. The FC-28 soil moistness sensor comprises 4-pins which are vcc pin rummage-

sale for control source, A0 pin is an analog output ,D0 pin is digital output and GND pin is powdered.

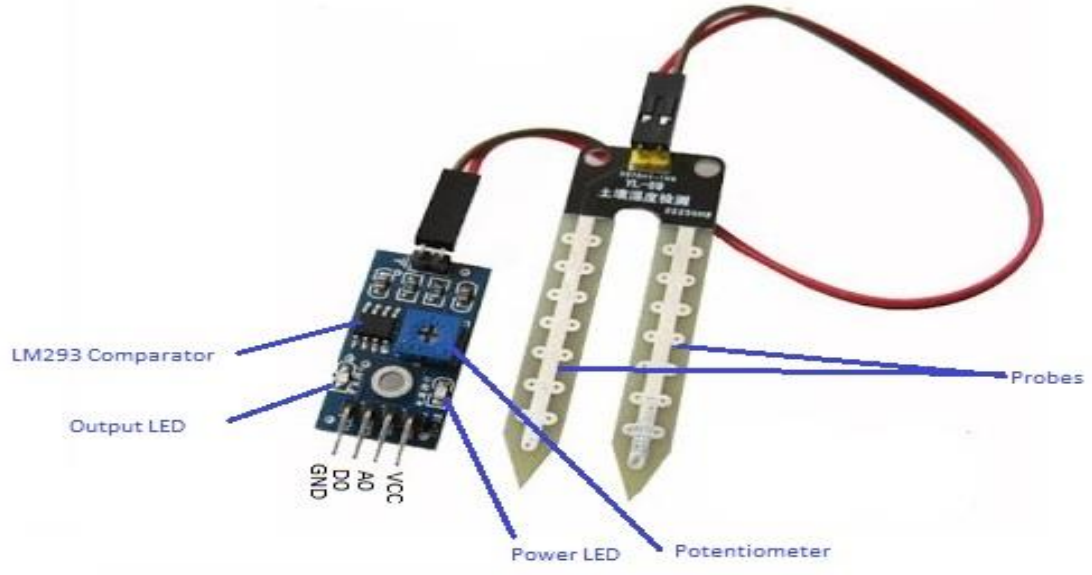


Figure 5 soil moisture sensor with jumper wire

2.2.4. Artificial Neural Network

An artificial neural network (ANN) is a computational perfect to achieve responsibilities alike forecast, categorisation, choice production. It contains of imitation neurons. These simulated neurons are a duplicate of humanoid intelligence neurons. Neurons in the intelligence permit the signs to do the activities. Likewise, imitation neurons attach in a neural system to do responsibilities. The joining among the imitation neurons is named as weight[27].

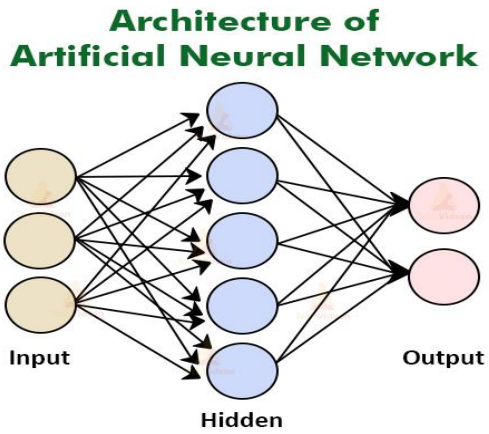


Figure 6 Architecture of ANN

Interconnected system contains of three coatings. The first coating is the contribution sheet which covers the contribution neurones that direct info to the concealed coat. The concealed coat does the calculations on contribution statistics then transmits the production to the yield coat. It comprises heaviness, activation purpose, and then value determination.

2.2.5. Thingspeaks.

ThingSpeak is an Internet of Things analytics stage facility that lets you to comprehensive, imagine, and investigate animate statistics watercourses in the fog. The data can be sent to ThingSpeak from devices, make instantaneous imagining of animate statistics, and send alarms.

Likewise Web Service (REST API) that leases gather and stock instrument statistics in the fog and grow Internet of Things requests , It is workings with Arduino, Raspberry Pi and MATLAB (premade public library and APIs is). It should effort by all caring of Program design Languages, meanwhile its usages a REST API and HTTP[28].

The ThingSpeak facility likewise leases to achieve connected investigation and performance on data. Instrument statistics can be directed to ThingSpeak since some hardware that can interconnect by means of a REST API. In this work have connected object via ThingSpeak API. ThingSpeak permits to shape requests round statistics composed by instruments. It permits data to be collected in actual period, statistics processing and it allows modest imagining designed for its consumers. Statistics are stowed in the networks which delivers the worker by a tilt of topographies. Every one network in ThingSpeak agrees the worker to stock up to 8 arenas of statistics, by means of active to 255 alphanumeric fonts each. Altogether arriving statistics is period and time printed and accepts a consecutive ID. When a station have

remained shaped, statistics know how to be available by gain access to the ThingSpeak API by a write key, a arbitrarily generated exceptional alphanumeric thread rummage-sale designed for verification. Therefore, a read key is rummage-sale to admission station statistics in instance it is usual to save its statistics secluded. Stations container likewise be complete community in which circumstance no speak key is obligatory. The things is an object given to the sensors for gathering the statistics. Statistics is directed and gained via simple **Hypertext Transfer Protocol** (HTTP) POSTs, considerably similar standard to a web page and satisfying out a procedure. This message occurs through plaintext, JSON or XML. The statistics is formerly uploaded to the fog and after here container can be rummage-sale for a diversity of purpose.

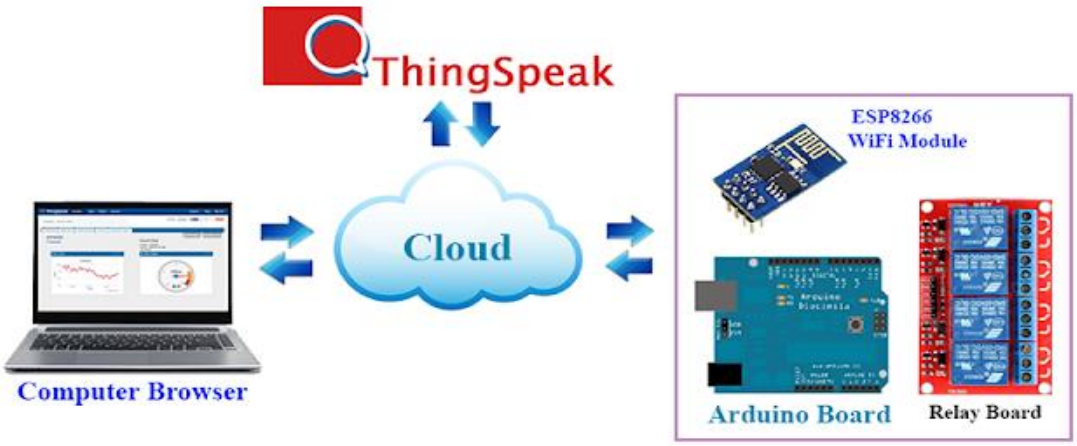


Figure 7 ThingSpeak connected with different hardware parts

2.2.6 Internet of Things

The internet of things is a scheme of unified calculating devices, motorised and digital technologies, substances, faunas or people that are provided with unique identifiers (UIDs) and the capability to transmission of statistics ended a system deprived of needful human-to-human or human-to-computer collaboration.

The object in the internet of things be able to be a individual by a emotion display insert, a farmhouse physical by a biochip transponder, an auto that consumes integral devices to attentive the motorist once exhaust weight is little or some additional usual or artificial thing that can be allocated an Internet Protocol (IP) speech and is talented to transmission of data ended to system[29].

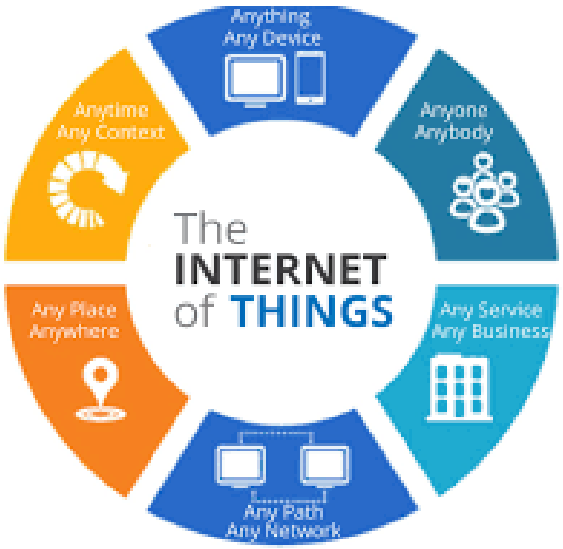


Figure 8 IoT with connected different things

CHAPTER THREE Water Usage Prediction Using Automated Home Garden watering system.

This part of project discusses the methodology that was used to address the research problem, research area, materials and methods used for collecting data and an IoT based on prediction of water usage in home garden watering system.

The project composed of hardware and software parts which being used in the system, Part of sensor nodes, NodeMCU and an Artificial Neural Network which is prototyped by means of MATLAB. The contribution limits which are Hotness, humidity and Soil moistness are showed, then by suitable methods, evapotranspiration and sort of flowers in the garden where quantity of aquatic wanted for watering is projected and now related outcomes are predicted.

3.1 **Artificial neural network** (ANN) stand for computational replicas that are enthused via the humanoid intelligence. Numerous of the fresh progressions have remained complete in the arena of Artificial Intelligence, containing Singing Acknowledgement, Double Recognition, and Automation by means of Artificial Neural Networks. Artificial Neural Networks remain in the nature enthused imitations made scheduled on the computer to carry out certain exact errands like Clustering, organisation, and Design Acknowledgement. The types of neural network in Artificial intelligent are based on the connection of the pattern, number of hidden layers, nature of weights and memory units which are 1, Feed forward and Recurrent ,2, Single layer or Multilayer, 3, Fixed or Adaptive 4, Static or Dynamic all these are being used depending on the data collected.

The system is using techniques of oversaw and unproven knowledge where the oversaw knowledge is used on behalf of training contribution statistics to the system and the wanted production is recognised as weights and are attuned until manufacture harvests wanted cost. While Unproven knowledge, the contribution statistics is rummage-sale to train the system whose production is recognised. The system categorises the contribution statistics and regulates the heaviness via feature removal in contribution statistics. The knowledge data set are composed of data train, data Validation, and Data tested[30].

3.2 System Components

This research work has 4 main parts:

A, Sensors side: Three different sensors are deployed: Temperature & humidity Sensors, dust moistness devices.

Different sensors are needed on the way to accomplish the prediction of aquatic needed in the garden. This research is considering the Jalia Garden data collected which has the different data according to different seasons of the three weeks. Where the sensors are deployed in the garden to collect data within different periods.

B, Gateway and Data Transfer side: Different communication channels are employed according speed, time, cost and flexibility (GSM, Wi-Fi)

ESP8266 with its built-in Wi-Fi is integrated in serial communication with the ATMega to enable the system to interact with the cloud applications through Wi-Fi and it makes it possible to establish a two-way communication with remote end- users.

The use of IoT devices and communication models (Wi-Fi) and its intelligence depends on data trains done by means of mechanism knowledge procedures ,consequently that the system is able to predict which water was needed for the future use a long time to come without getting daily repeated same data from the garden[31].

C, Cloud side: the integration of Cloud for further data processing and visualization by using NODE-RED based dashboards, data study and analysis and storage for future use. The end users' Personal Digital Assistants i.e. Laptop, Smart phone, tablet fully connected on the internet, this simplify the work of the management and increase the awareness in remote analysis of the water consumption to take measures where necessary.

The system itself would take decision based on the comparison between pre-processed data and real time parameters measurements.

On the other hand, the information was sent to the owner of the garden to tell them that there is problem for quick to solve it and also the supplier side to help him/her know the amount of water needed for future watering.

To implement this effort, soil moisture device and temperature & humidity are rummage-sale as contribution statistics of the scheme. NodeMCU ESP8266 is rummage-sale by way of storing of statistics then of the scheme. The raincloud stage (Thing speak) is rummage-sale to stock, imagine then analyse the living statistics congregated by means of devices. USB Modem stage is rummage-sale to direct attentive notice to the user of the garden.

An **artificial neural network** (ANN) is the measure of a calculating scheme deliberate to pretend the technique the humanoid intelligence scrutinises and procedures info. It is the basis of **artificial intelligence** (**AI**)[32] then answers difficulties that would demonstrate impossible or problematic by humanoid or arithmetical values, by that way that why ANN was preferred to be used in system which was trained by MATLAB.

MATLAB is a high-performance linguistic aimed at practical calculating. It assimilates calculation, imagining and software design in an easy to use surroundings wherever difficulties and answers are uttered in acquainted mathematical notation. Characteristic usages comprise: Mathematics and working out.

There after by the use of MATLAB Environment to train Artificial Neural Network (ANN) algorithm the quantity of aquatic wanted for watering is projected and then related consequences are decided. The measurement thresholds of water used, temperature and moisture of soil was being set basing on the climate and pre-recorded data from Meteo Rwanda and also pre-recorded data from garden.

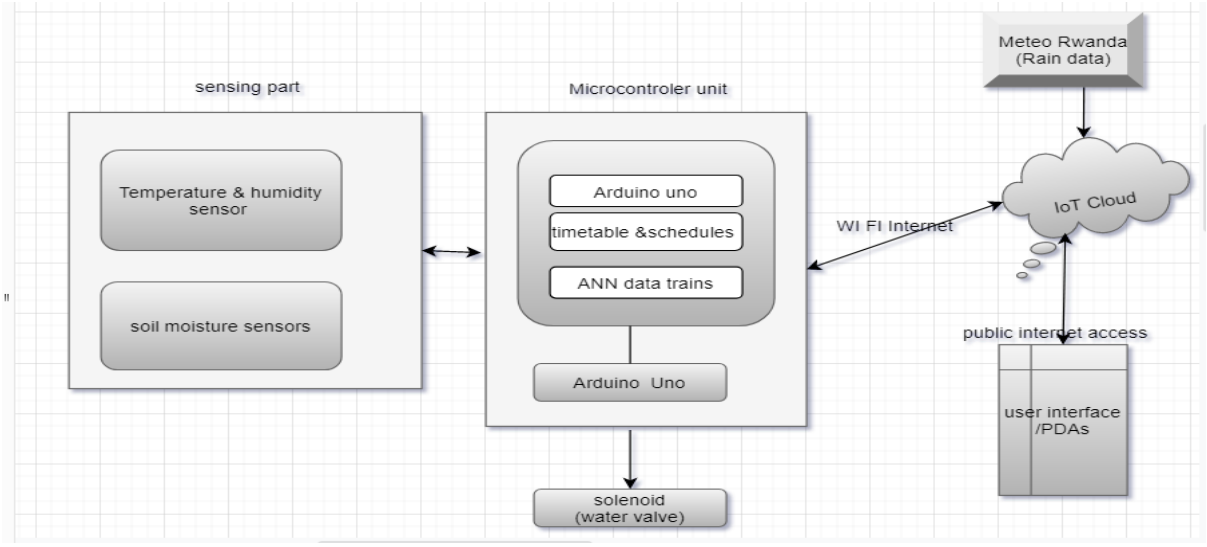


Figure 9 concept view of the system solution

The system is having three types of input data

- Data from sensor nodes
- Data from Meteo(weather data)
- Data from previous manual watering (watering based on climate change timetables and schedules)

Due to the Intelligence of this system, the **output are**:

To regulator the aquatic pump (turn ON / OFF water pump), it is controlled in two ways, the decision from Microcontrollers Unit or the decision from end user through PDA interface.

The artificial Intellect and Mechanism knowledge have been the advanced technology concepts introduced to deal with supervised and unsupervised learning systems, data mining, neural networks and rule based computation, different algorithms are deployed to train the system basing on the recorded data, these include, artificial neural networks and other evolutionary procedures.

Through this research, the ANN was running on NODE MCU as its features enable it to host Machine learning algorithms and the training data becoming from Meteo Rwanda (weather data of Kigali city) and the previously recorded data using manual recording method.
ANN is an interrelated collection of nodules, enthused in simplification of neurons in an intelligence. Every one globular nodule symbolises an **artificial neuron** and an arrow

symbolises a joining from the amount produced of one **artificial neuron** to the contribution of dissimilar.

The ANN model involves programmed knowledge of dependences lone from slow statistics deprived of some essential to enhance additional info[33]. The neural system is qualified from the historical statistics (or from the environment data that is data collected from the sensors) with the confidence that it was determine by concealed addictions and that it was talented to use them for forecasting into upcoming.

The ANN is characterised in different ways which are

- An Artificial Neural Network involves of big numeral of "neuron" similar dispensation rudiments.

- Altogether dispensation rudiments consume a big quantity of prejudiced influences among them.
- The networks among the rudiments deliver a dispersed symbol of statistics.
- Education Procedure is executed to obtain information.

The Artificial Neural Network (ANN) has three different basic elements that was used for the system which are as follows;

- Processing Elements
- Topology
- Learning Algorithm

Processing Elements.

As the ANN is a basic computational perfect of a organic neural net, an ANN involves of rudimentary dispensation components or rudiments like to that of neurons of intelligence.

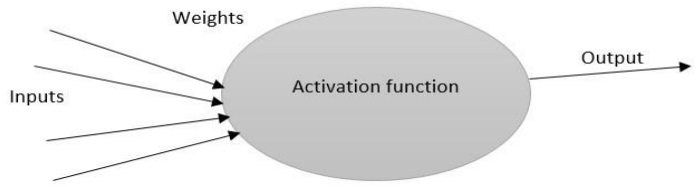


Figure 10 Sketch of ANN

In this system, a dispensation component is complete up of summing component shadowed via production component. As the purpose of a summing component is to income contribution standards, heaviness every contribution worth and compute the biased amount of those standards.

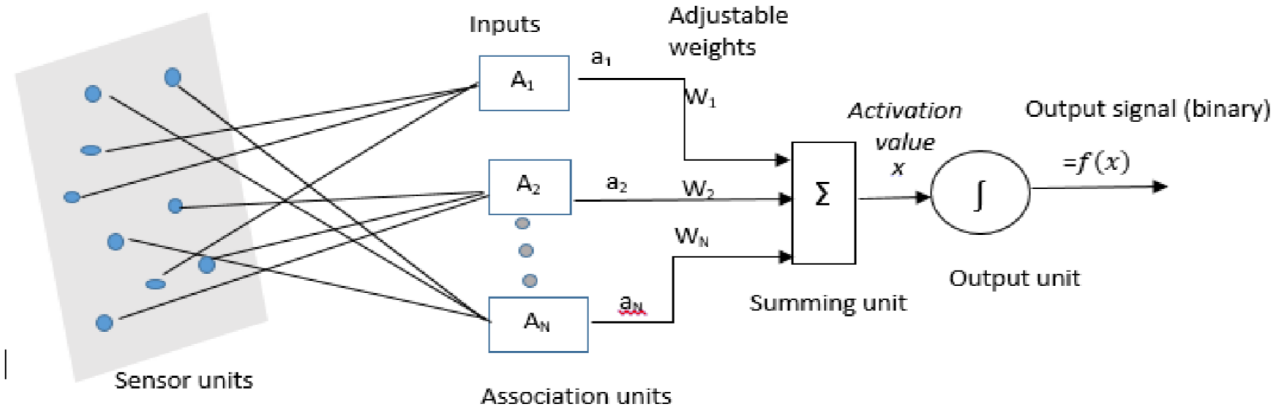


Figure 11 Functioning of an ANN

Founded on the symbol of the mass of every contribution, it is strong-minded whether the contribution consumes optimistic weightiness or undesirable weightiness. The summary of the biased component is recognised as Activation Worth and founded on the indication from this initiation worth, the production is shaped.The aquatic wanted via the garden can be unequivocal using dissimilar measurements such as soil moistness, high temperature,

humidity. Scheduling parameter required for watering was displayed by the developing system An automatic watering scheme mentions to a plot anywhere altogether features of garden are mechanical. The information regarding garden are Temperature, Humidity and Moisture which was being processed through NODEMCU and uploaded to cloud using artificial neural network module, where data from cloud can be extracted by user and then can monitor real time data of garden for watering and specific amount of water to be used.

Topology

Any Simulated Neural Net was valuable lone once altogether the dispensation rudiments are prearranged in proper way consequently that they can achieve the chore of design acknowledgement. In other word Topology is procedure of the processing elements the data from the sensors, their interconnections and their inputs, outputs. Usually, in an ANN, the dispensation components are decided keen on coatings and altogether the components in a specific coating consume the similar stimulation standards and production standards. Joining container be prepared among coatings in manifold habits similar dispensation component of unique coating linked to a component of additional coating, dispensation component of a coating linked to a component of similar coating. Commonly used topologies in ANN are Instar and Outstar topology.

Figure 12 type of paspalum used in research

Learning Algorithm

The last and significant rudiments of any ANN are Education Procedures. The process any neural net is lined by Neural Dynamics containing of together start national subtleties and synaptic weightiness diminuendos. Education Procedures are applications of synaptic dynamics and are labelled in footings of chief copied of the weightiness. These inclined rules can be oversaw, unverified or a hybrid of together.

The Learning of a humanoid intelligence is just recurrent start of convinced neural influences and this replication reinforces the joining. So, for a quantified contribution, the neural influences brand unquestionable that production is continuously a wanted unique. A humble response after the consequence assistances the education procedure as it reinforces the neural influences. MATLAB it is programing language used to train data that is stored in the database or Server by use of Non-natural Neural Nets as they only strain to duplicate this achievement of the skilled statistics.

3.2.5. Hardware schematic diagram

The prediction of water usage in automated home garden watering scheme consumes remained built and collected on NODEMCU in the shop. The Figure below illustrate the hardware connection of the data collected in the system where, DHT sensor and soil moisture sensor have been connected to the NODE MCU to collect data from Jalia Garden and test the data which was being monitored using Arduino IDE as software, Dashboard and XAMPP software as online services for storage. There is also water pump which will be used pump water when it is needed.

Figure 13 Equipment's used in the system

3.2 2.Software part

Software share contains of the software design wanted for the NodeMCU to achieve its mission. Procedures are printed to set in what way the microcontroller workings and responds rendering to the dissimilar situations such as interpretation the contribution indication from the device and blinking of LEDs and triggering transmit once apprehension occurs. Aimed at software request, whichever java software design consumes remained designated as the chief software rummage-sale for the NodeMCU. In command to attain these aims, a portion of firm effort is obligatory to package the software. In the procedure of finalizing the scheme, responsibilities similar tour scheming, verdict mechanisms, building archetype and testing the functionality of the archetype is done.

XAMPP is the greatest common PHP expansion setting which is informal to connect Apache delivery holding PHP and Perl. The XAMPP is the exposed basis set which consume remained usual active to remain tremendously informal to connect and usage.

The PHP and C/C++ **NetBeans** packages lone need the **Java** Runtime Environment (**JRE**) 8 to remain connected then route. **JDK** 8 is obligatory uncertainty you are organising toward usage of some of the **Java** topographies. **JDK** 8 is obligatory to usage JavaFX 8 topographies in **NetBeans** IDE **8.2**.

These programming languages are used to run the system and get data from the NODEMCU to be used in the database of the system which is the Local host and it is used to train the data collected from the garden to be compared to those of Meteo for future use.

CHAPTER FOUR. SYSTEM DESIGN AND ANALYSIS

In this chapter talked about the designing system of the project, how the system is functioning, how the sensors are interfacing with the microcontroller, how the Devices remain linked to NodeMcu ESP8266 and the system technology used.

This system is used for prediction of water usage in the Garden and to inform the consultants via observing the aquatic usage consequently that it is checked unceasingly period to period by use of dust moistness, temperature and moisture devices according toward the season of sunny

or wet. The statistics took via these devices remain efficient in the web request dashboard. If the aquatic usage needed, the system trigger to automatic water the amount of water needed by notifying the amount of aquatic wanted toward the authorities / the owner of the garden and pump will be opened automatically.

4.2 THE APPROACHES USED

In this scheme converses the methods that remained working to gather the statistics contribution and verdict creation and the output of the data required in the Gardens. The fillings of this investigation episode comprises: a summary on the investigation goals and objects, investigation scheme and the mechanical likenesses of the training.

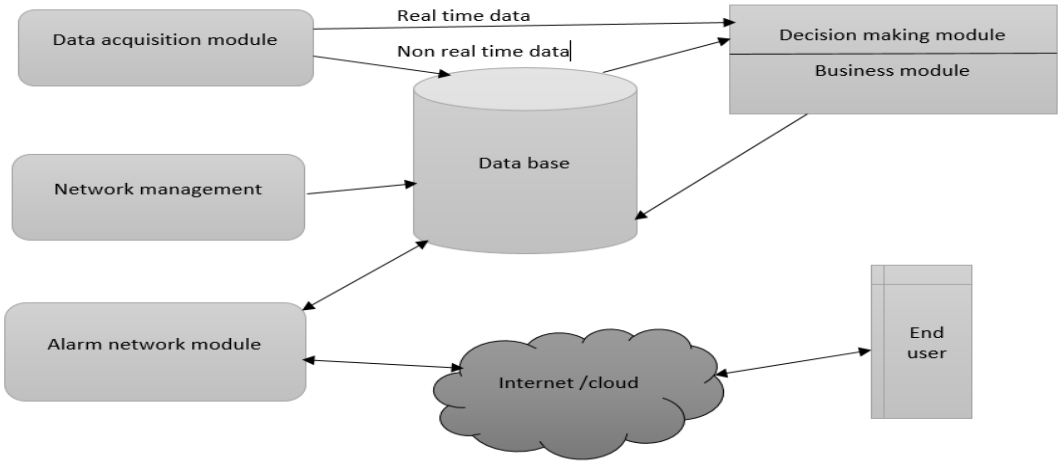


Figure 14 System Design

The system design has five parts of modules, one is Data Acquisition modules, Network Management modules, Alarm network modules, Decision Making Modules and Business modules,

In Data Gaining would be used for real time and non-real time of data which would be used for get-together data from sensor network where it would be stored in database for decision making. The displaying of info to the finale user is carried out by Apprehension Net where it is workings by way of admission opinion among finale user and additional nets.

In System Managing is used for the localisation and network configuration where there are concept of machine to machine (M2M) message anywhere aquatic usage are preserved by using bright device net and well-organized direction-finding procedure.

The management of the system consists Database, Applications and web waiter, Statistics collected from the devices are being conventional via request waiter which are then stowed in the databank where as Web waiter are being retrieved via owner of Garden though smart phone.

4.3. HARDWARE COMPONENTS THAT WAS USED ARE;

4.3.1. NodeMCU

Nodemcu is similar Arduino IDE which consumes the whole pin-making as Nodemcu panels. Behindhand the panel can be able to find the real GPIO PIN which brands it actual informal usage through some compiler programming. It consumes actual significant Wi-Fi API that lets it to attach through additional plans and to access info from the internet and let a operator to switch a device from wherever or from some share part of the world[34]. Nodemcu can provide lone unique ADC which incomes it has lone unique analog pin. The ADC pin is consuming a 10-bit resolve, which container read 0 to 1024, where you can get a value anywhere inside this range. The ADC pin reads up to 1V lone.

The assimilation among the software and hardware is complete by means of a nodeMCU ESP8266 with the IoT part, nodeMCU consumes uploaded the draught of the coding of moveable telephone request Wi-Fi ID and Wi-Fi PIN, this lets nodeMCU to procedure the Wi-Fi unit to join the Wi-Fi and formerly join to the modem apps. Through to join the mobile phones, the nodeMCU profits the coding which performances by way of the supervisor to switch the connotation of the scheme such as allocate soil moisture sensor, temperature & humidity device as the contribution data and procedure the contribution in the nodeMCU to recognise the present aquatic used and refer statistics to mobile phone.

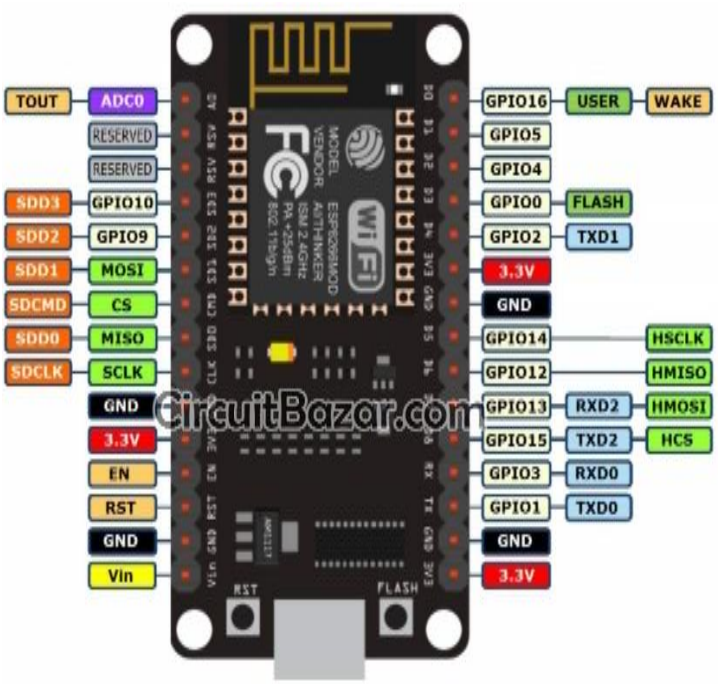


Figure 15NODE MCU

4.3.2 Soil moisture sensor: This soil moistness device is a modest escape board aimed at gaging the moistness in dust. Applications include automatic plant watering systems and more. This dust moistness device is a guileless getaway board used for gaging the content of soil with in garden.

The twice enquiries doing as a mutable resistor. Once the dust is dehydrated, the production voltage is upper. It works in two modes, the digital mode which simply detects the presence of water and outputs a 1 and an analogue mode which is more accurate. Applications of this sensor include Automatic watering systems and more. Connect VCC and GND pins to NODEMSU or any microcontroller you are using and connect pin A0 to an analogue pin of your microcontroller.

One drawback by using this device is that its superficial gets rusted effortlessly so it is a good idea to place it in “snooze method” the code and power is needed only when you are reading. This dust moisture finding element is fortified by potentiometer and dust moistness verges.

It container mechanically aquatic plot, household floret acnes below dust moisture switch. Progress presentation of transmission, avoid interaction through the dust from corrosion glitches and spread lifetime.

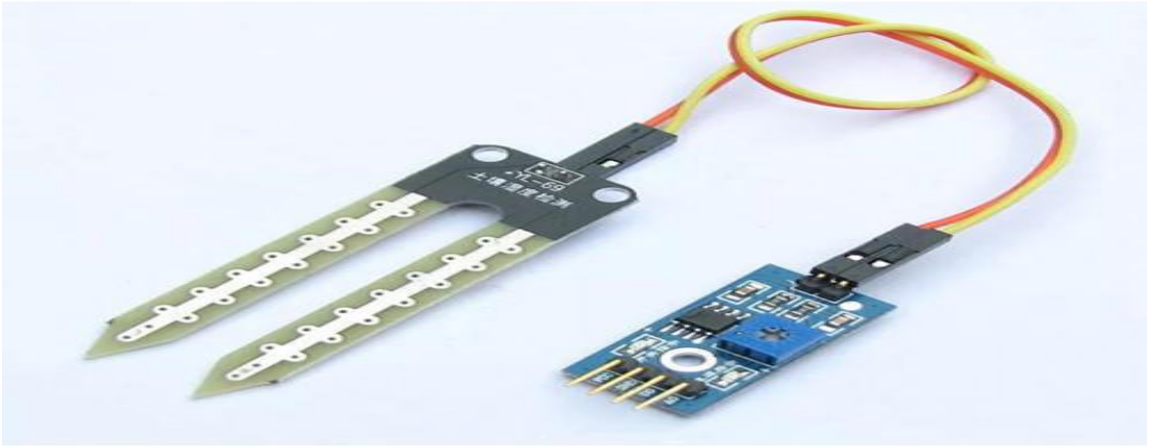


Figure 15 Soil Moisture

4.3.3. dht11–temperature and humidity sensor

Difference between DHT11 Sensor and module:

The **DHT11 sensor** container whichever remain acquired as a sensor or as element. Whichever method the presentation of the device is similar. The device determination come as a 4-pin set available of which only three pins determination will be used whereas the unit resolve come with three pins as revealed above.

The lone alteration among the sensor and module is that the unit resolve consume a sifting capacitor and pull-up resistor inherent and aimed at the device, you consume for usage of them outwardly if compulsory.

The **DHT11** is a characteristically rummage-sale Temperature and moisture device**.** The device makes through a devoted NTC to degree hotness and an 8-bit microcontroller to yield the standards of temperature and moisture as sequential statistics. The device is too sweatshop regulated and henceforth informal to border through additional microcontrollers.

The device container extent temperature from 0°C to 50°C and moisture from 20% to 90% through correctness of ±1°C and ±1%. So if you are observing to amount in this variety formerly this device strength be the correct excellent aimed at you.

DHT11 is rummage-sale to Amount of temperature and moisture, Limited Climate position, involuntary weather regulator and Surroundings checking.

Pin Credentials and Configuration:

No:	Pin Name	Description
For DHT11 Sensor		
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and moisture through sequential Data
3	NC	No Connection and hence not used
4	Ground	Connected to the ground of the circuit

Table 1 Identification of configuration

For DHT11 Sensor module		
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and moisture through sequential Data
3	Ground	Connected to the ground of the circuit

Table 2 DHT11 sensor modules

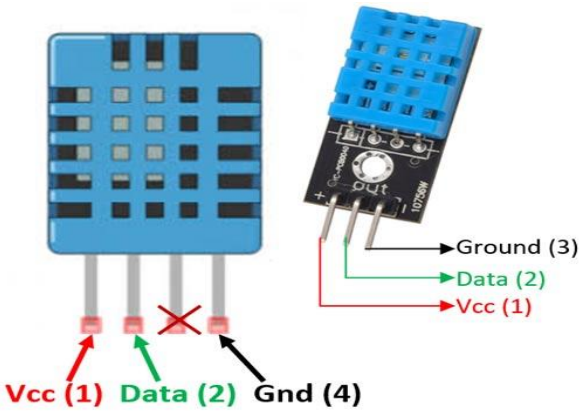


Figure 16 DHT11 Pin Port

4.4. FLOWCHART OF THE SYSTEM.

The execution follows the canon and regulation stated throughout the plan and it was approved out in Kigali city, Gasabo district, and Rusororo sector at Jalia Garden. The outcome of this plan would remain a model that remained modified to mark the possible vicissitudes in the necessities owing the adding of new-fangled necessities or profounder clarification of the wants that increase.

Rwanda has two seasons of weather, the season for sunny and season for winter, if it is season of winter the water supplied to the garden is less than the water supplied in the summer. The system was predicting the amount of water supplied from the input data which was being processed and analysed by cloud to get exact amount of water to be supplied per day, The system was automatically knowing that is going to use 20metres cube per day accordingly as it is shown in figure below where **H** stands for amount of water needed to be supplied in the Garden.

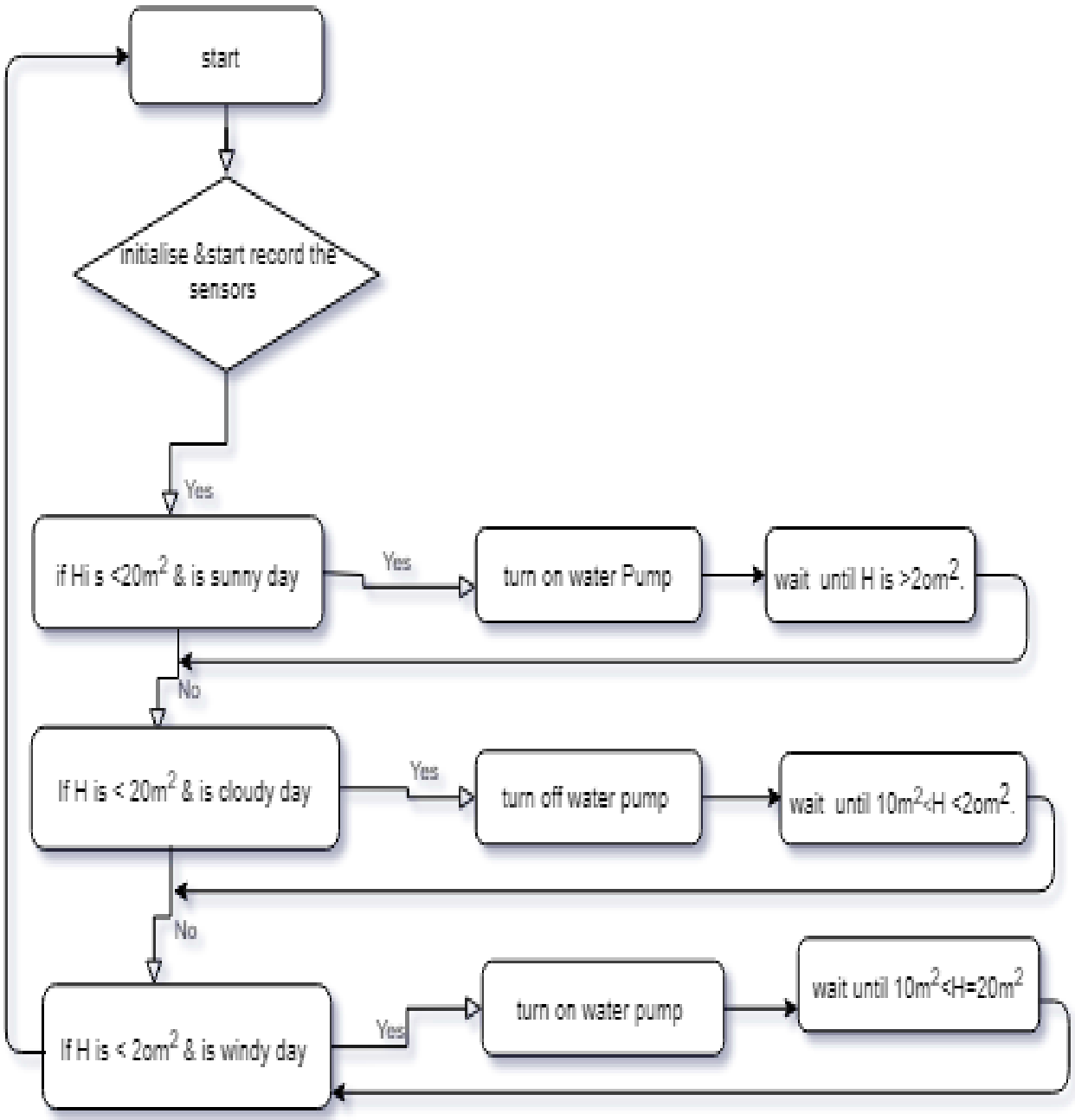


Figure 17 Flow chart of the system

In this flowchart has different steps according to the prediction of water usage using automated home garden watering system which are:

First, Sensors that is, moistness device located in the dust, temperature device, humidity device sanities the present standards and directs the statistics to statistics gaining scheme which is microcontroller.

Second, these data are processed using codes which helps to predict the water usage of the garden and output is passed through microcontroller.

Third step, in accord with the contribution established in the microcontroller it jumps taking the next actions, if the moisture device interpretation is fewer than to critical worth for an exact plot the water drive for that specific area of the plot is turned on. If the climate forecast turned out to remain a sunlit day, the aquatic drive are turned on until the moisture device reaches the set point worth. And formerly if the climate stretches the info that the option to rain is less than 20m2 then the water pump turned on until the moisture sensor reads that value of moisture gratified is in among 10m2 and 20m2 so as to evade harm water used in the garden when watering.

If the weather is cloudy that the rain is going to fall if the option is upper than 20m2, then the water pump turn off until the rain stops and checked to the system if the soil moisture is still wet.

CHAPTER FIVE: EXPERIMENTAL RESULTS AND ANALYSIS

The prediction of water usage in the garden scheme testing is approved out through showing a joining test which comprises sending the statistics to the database. Statistics in the procedure of analogue signals providing through devices are directed to the database via NODEMCU. The period that is necessary to direct statistics is 15 to 20 seconds.

The scheme examination defines the scheme effort and scheme in over-all where the scheme plan clarifies the substantial necessities for the plan of prediction of water usage in garden by use of automated home garden watering systems and the design of how water will be needed in the systems.

The rapidity of distribution statistics is pretentious by the distribution period (distribution info period) and too the reply from the database in dashboard. Also these two issues, the rapidity of the statistics broadcast chain is too influenced through the cellular grid signal. Statistics sent on the database is showed in a dashboard /local host where it would be accessed through desktop or smartphone as shown in the figure below

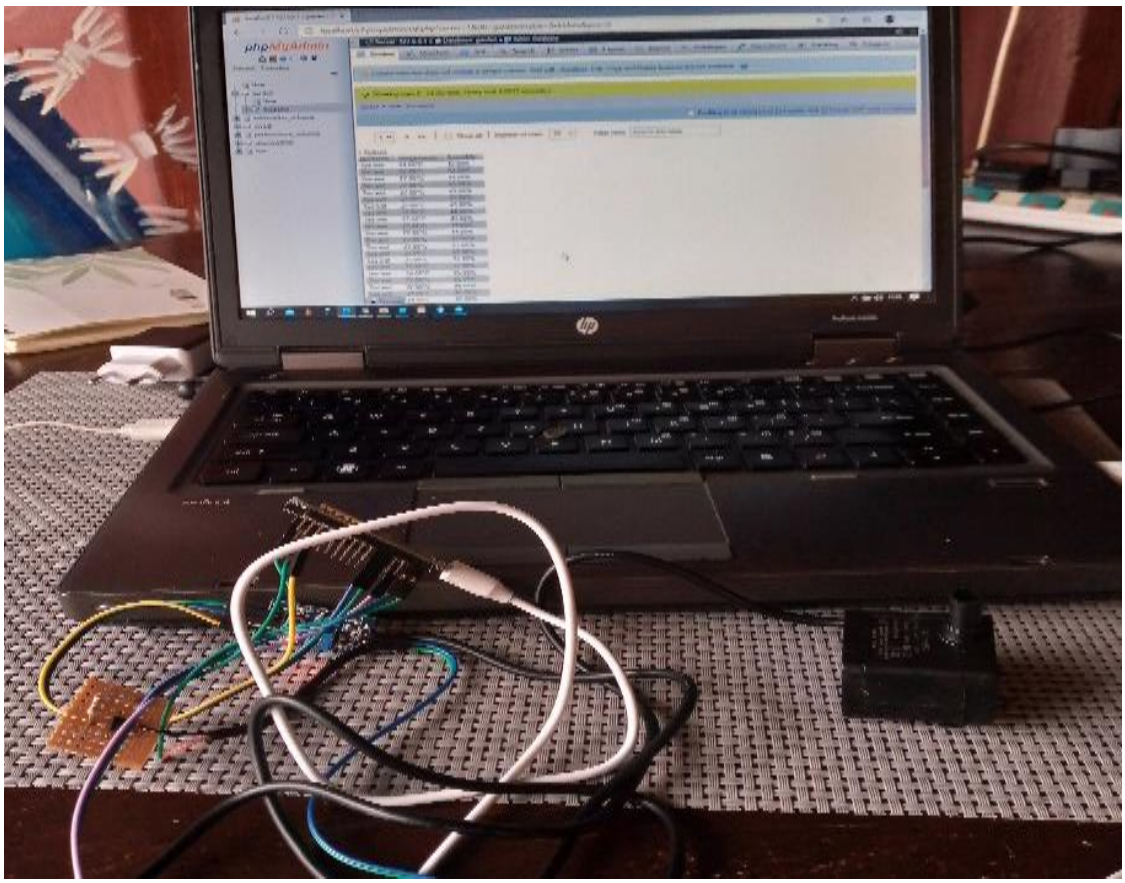


Figure 18 Systematic Sketch of the System

Figure 19 the deployment of sensors in Garden

Figure 20 Watering in the Garden

From the figure 14a above there is deployment of the sensors in the field where different data are collected according to the type of soil content and there is also battle of water to test the pump is spraying water during the watering system.

In figure 14a there was testing of pumping water according to their codes where it was pumping after 15 to 20 seconds if it finds soil dry.

5.1 Graphical Outcomes.

The Figure 15 (a.b) below demonstrations outcomes from ThingSpeak website of soil moisture. It is exemplified with two graphs which indicates the animate composed statistics in two different sites of the Garden.

Therefore by manufacture an intellectual investigation of watering in the garden, dissimilar soil circumstances were measured where the figure 18a shows soil is Wet and figure 18b shows soil is dry and those data are taken for preparing the statistics set relating to soil moistness and hotness and so forecasting the soil created on actual time data conventional for activating the impel for watering the garden.

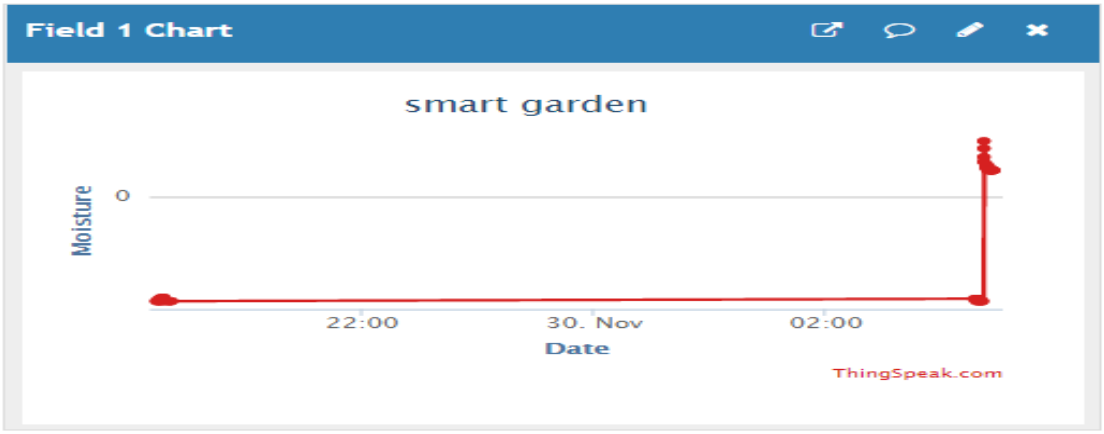


Figure 21 moisture wet

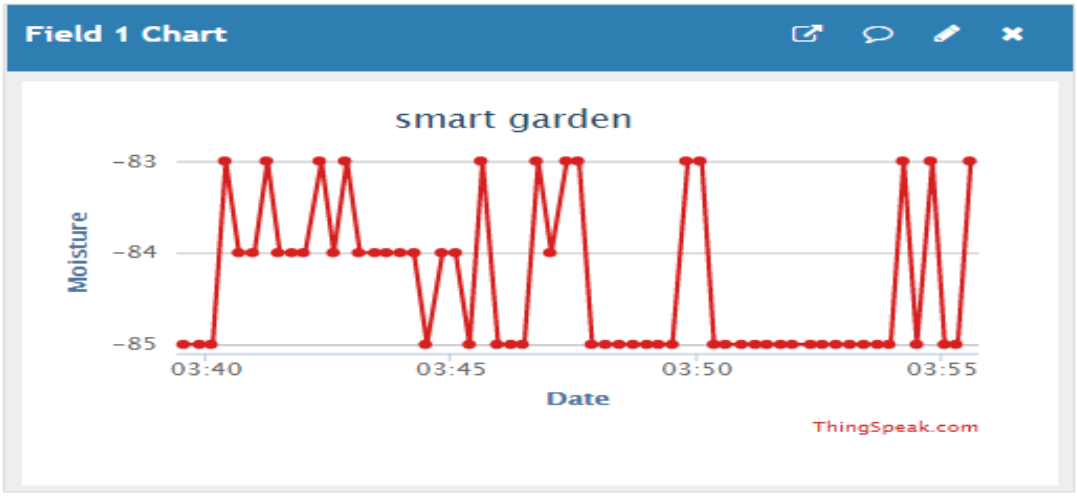


Figure 22 Moisture dry

It has two main components, the location of the prediction of water usage which is the location of the placement of the automated home garden watering system and the indicator of the real-time displays the reading of the program that is used to collect data.

In the figure below 17a and 15b shows the graph of temperature variation where figure 17a read the temperature it's not too hot which means soil moisture is wet whereas graph 17b shows the temperature has been changed to constant value.

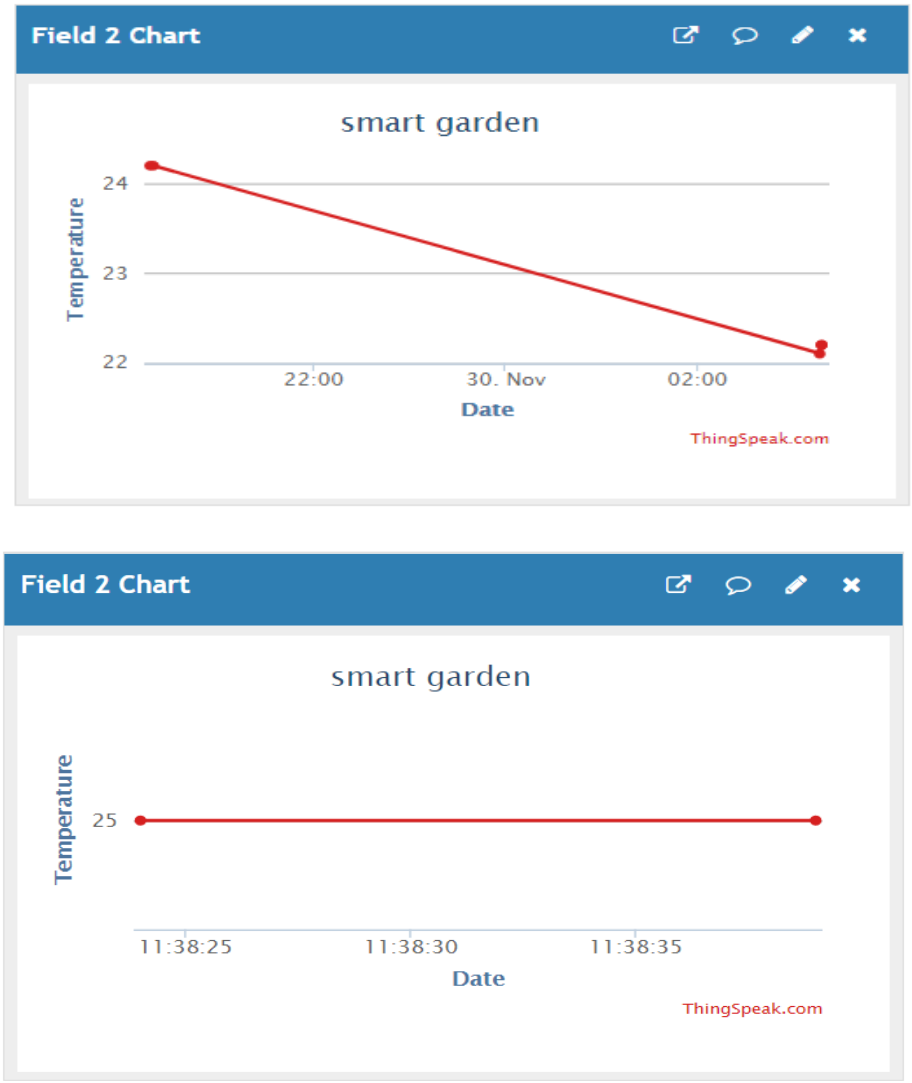


Figure 23 Temperature

In the figure18 below shows some changes of the humidity and if humidity increases it means that the soil content is good.

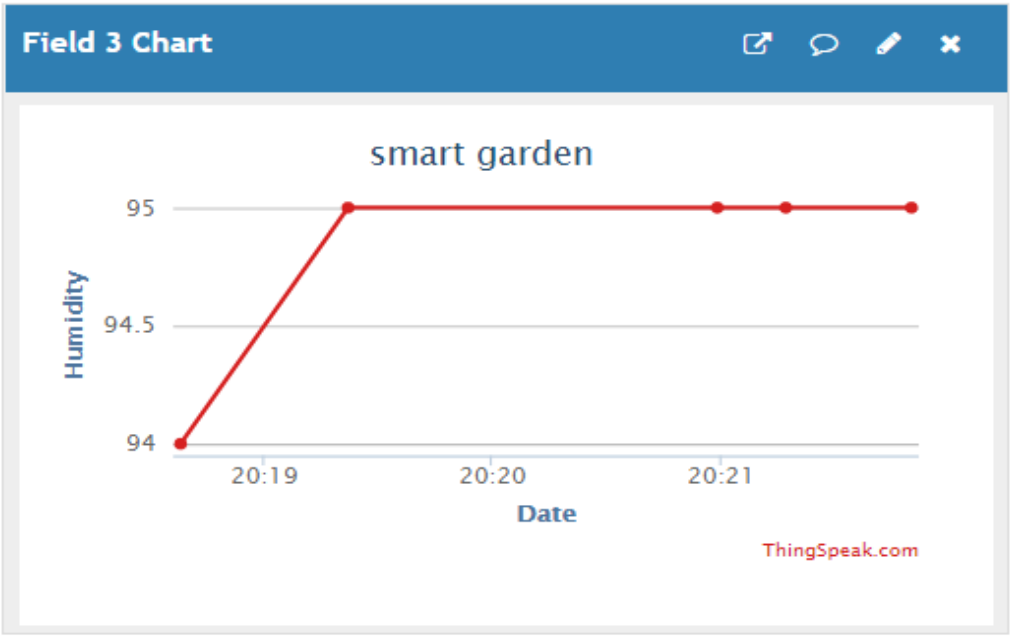


Figure 24 Humidity

Lastly the studied data lengthways with garden watered are rationalised in Thingspeak which leases the user recognise the situation of dust and likewise aquatic existence watered. This can be gain access from moveable phone. Likewise chart data page of moistness against hotness and CSV file relating to qualified statistics set are kept in Thingspeak also.

After ANN machine learning predicted the soil situation based on the soil moistness and Hotness level then forecast harvest is used for distributing the regulator indication through the sequential message to microcontroller for regulatory water push for watering garden accordingly.

The first and latter module of footage the soil moistness and Hotness measure and forecast with period of time in the fog server for user to admittance from their moveable to take good information and considerate on how garden was watered.

5.2. Results Analysis with Matlab.

Matlab is a high-performance language for practical calculating. It assimilates calculation, picturing and program design in an easy to use where difficulties and resolutions are expressed

to be used to mathematical representation. It is used to train data fetched from the garden to get the target data needed to be used. The Algorithms that used are data division, training of that data and their performance to be calculated.

The data fetched from the sensor node of the garden are being saved to comma separated values and is trained every after a week to get amount of water needed to the garden. The targets for training are used to help the neural network understand that these are the outputs needed. They are not used while testing. Testing phase is when your previously trained network is now classifying new unseen data. And even the validation of neural network needs targets data. These all is being already done by the neural network tool. It splits the dataset into training, validation and testing. That is how it validates itself.

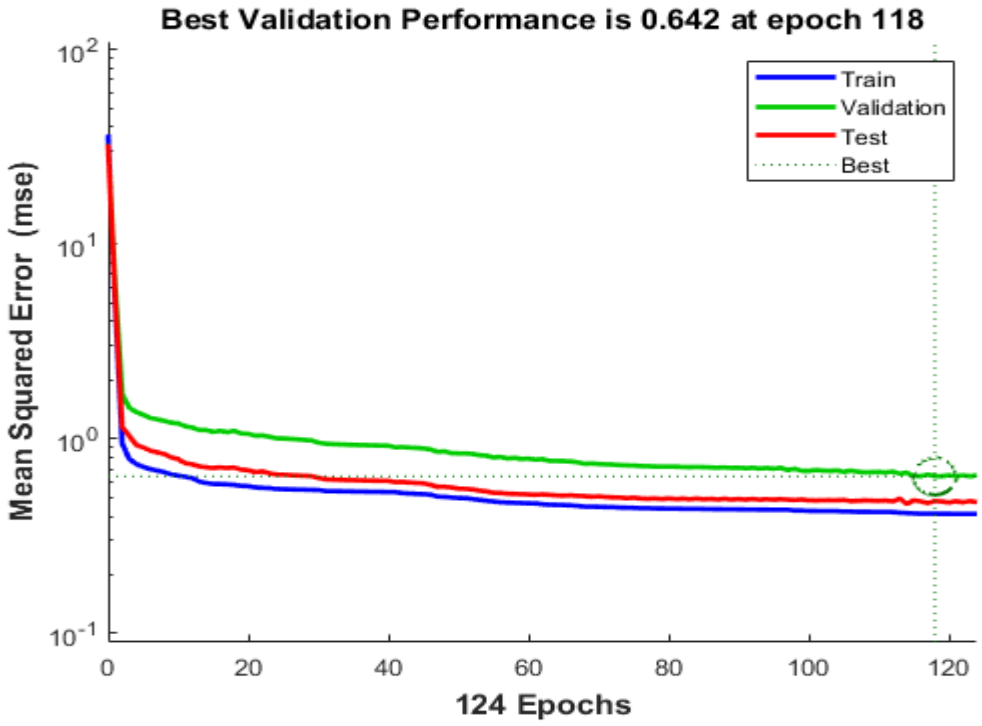


Figure 25 best validation performance

According to the figure below there are three input data where data are being trained to the hidden area to get real one target output and its neural network where fetched data are being trained.

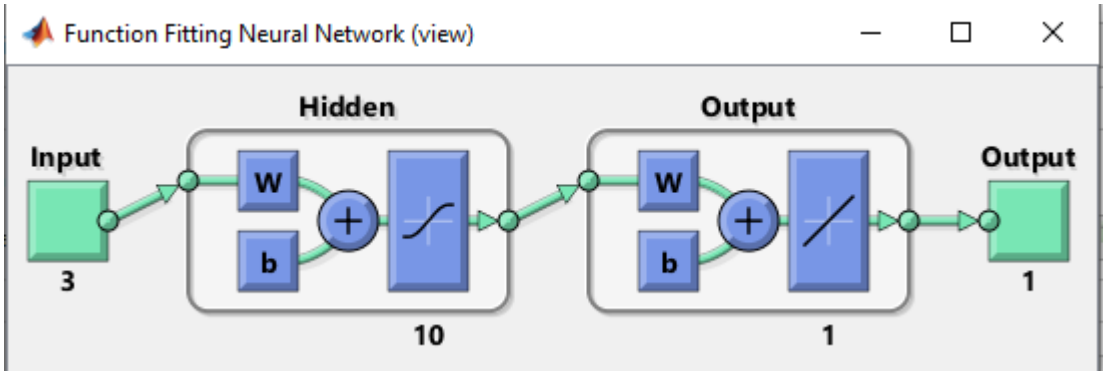


Figure 26 Functioning of neural network

In the figure below there are different measures of Artificial Neural network (ANN) Supervisor is implemented using the next dissimilar steps of Topology: Dispersed Time Delay Neural Network is rummage-sale, Training Function: Bayesian Regulation function is rummage-sale for training and Presentation: Amount squared mistake is taken as presentation amount, Goal: The set goal is $0.01m^3$ per day per one meter squared land with paspalum, Learning Rate: The learning rate is set to 0.05. When the obligatory soil moisture surpasses the measured soil moisture the valve is opened and it remains closed otherwise.

According to the figure below there are values of gradient from the trained system and and its validation checks which is equal to 6 It show that where there is high pick means there is change of input data in system trained where all the inputs data can be at the same level with slow changes.

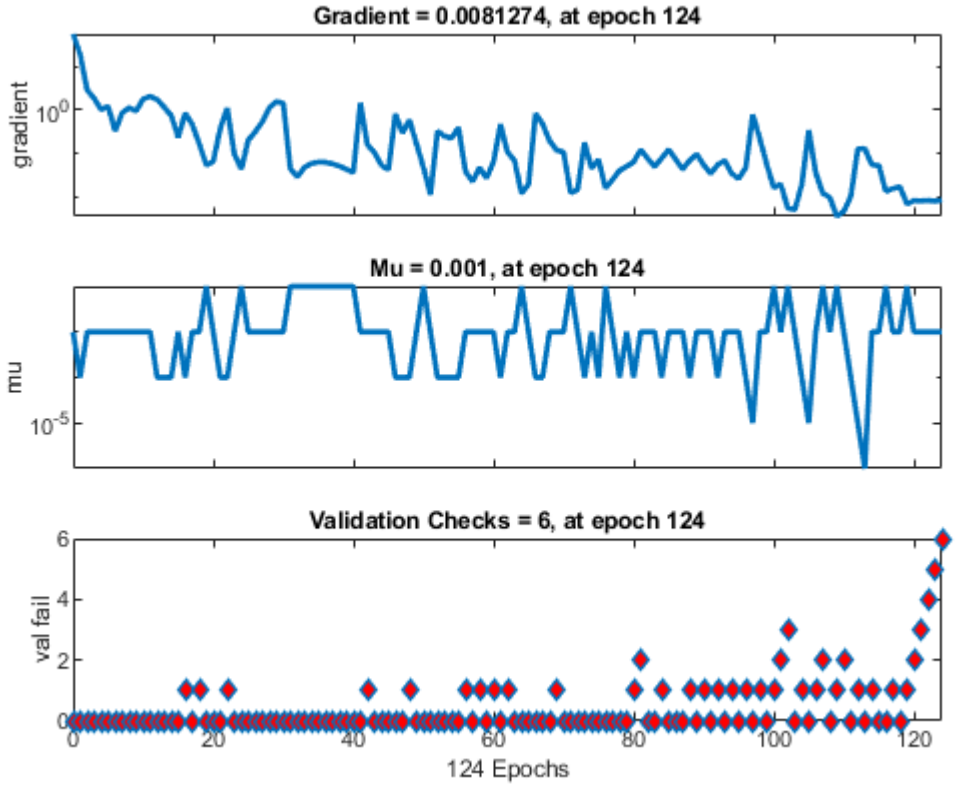


Figure 27 ANN training state

In the figure below show the system is success fully trained because it has the same data which was trained by matlab in the use of artificial neural network, where the trained data is the same as validation data which is also same to the tested data of the system

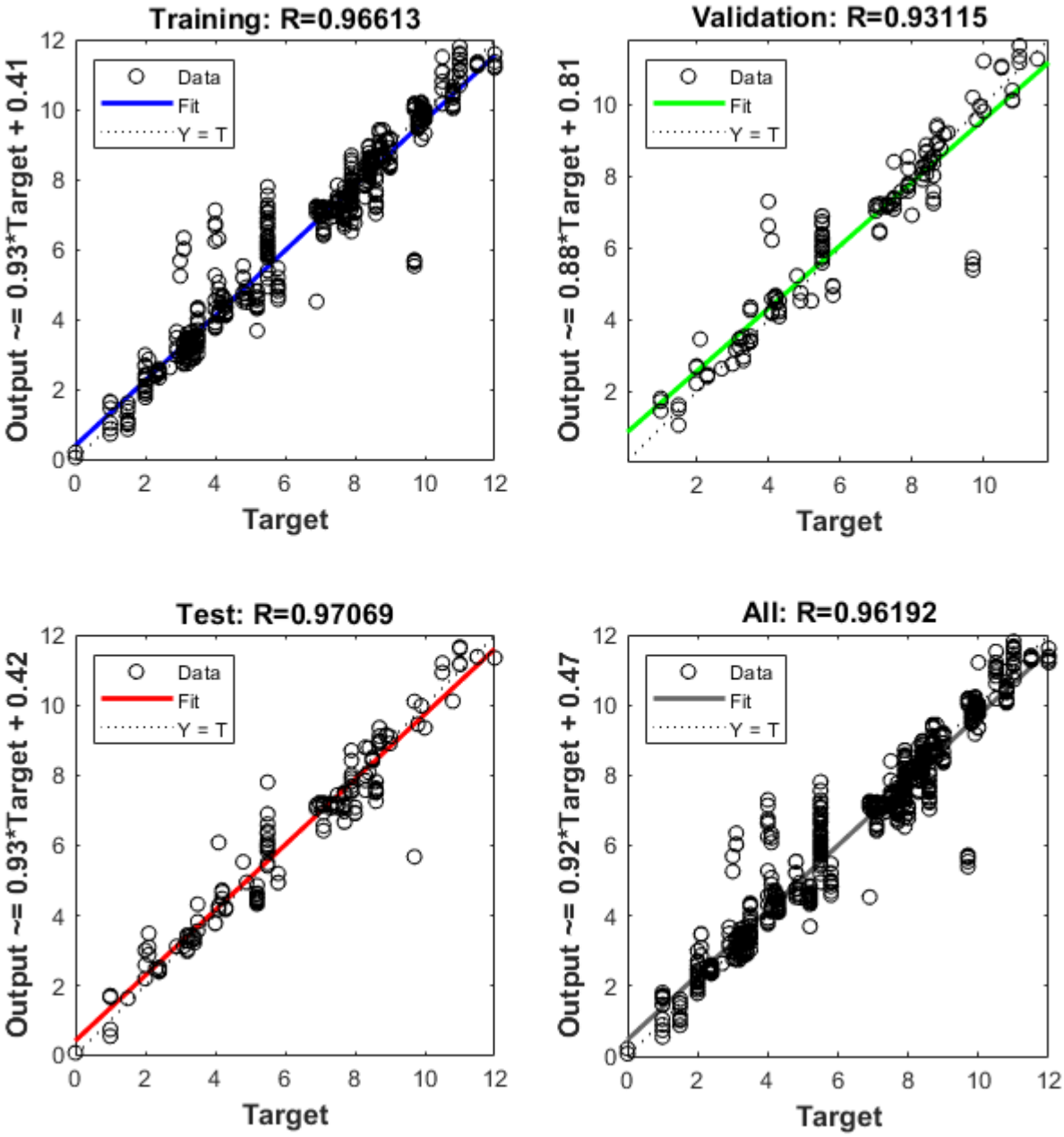


Figure 28 regression line

In the figure below shows the trained amount of data in the system which is needed to be watered in the garden according to the input data fetched.

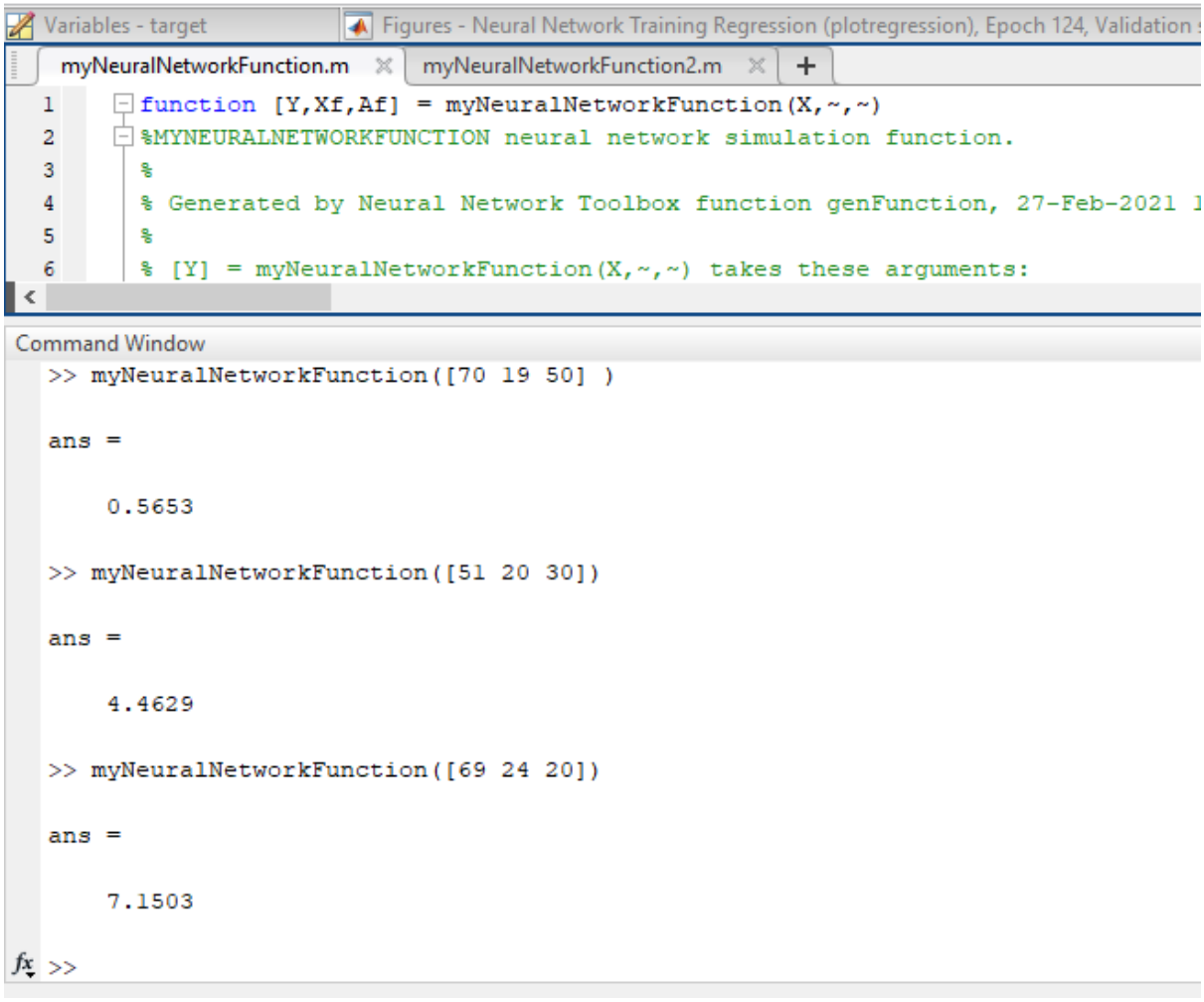


Figure 29 Output results

The figure below shows access to the Administration of the system where it was able to access all conditions that are taking place in the Garden.

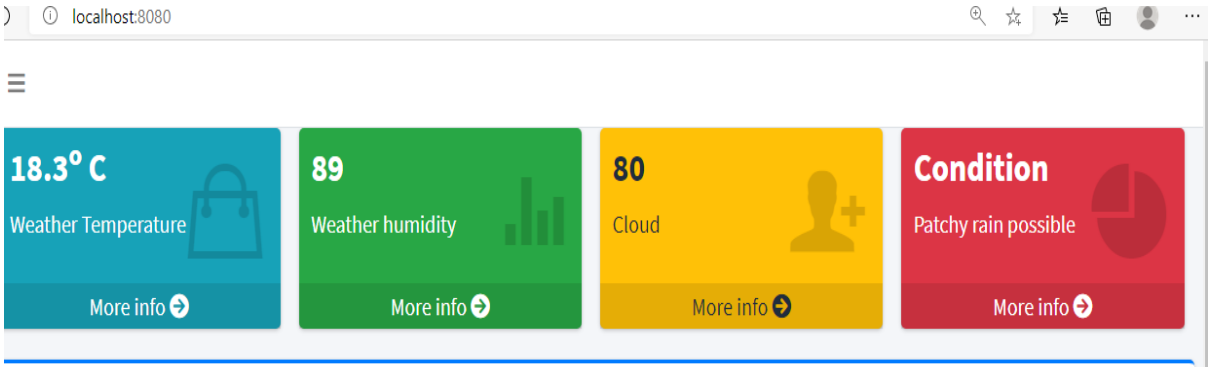


Figure 30 Admin Access

The figure below shows the how the soil content is predicted if soil moisture leads negative values it means soil is dry where watering is happening automatically according to the amount of water needed , whereas leads positive value it means soil is wet the pump switch off automatically

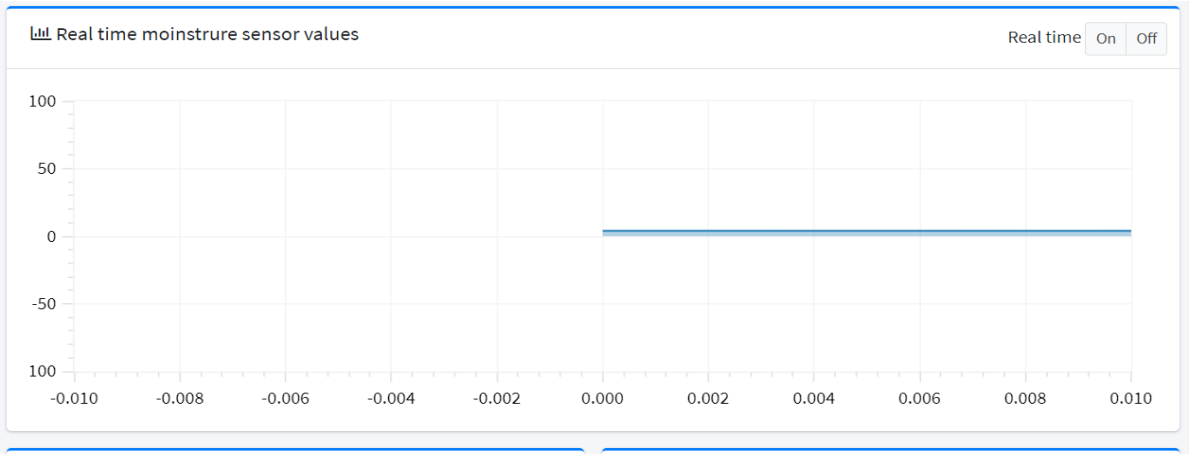
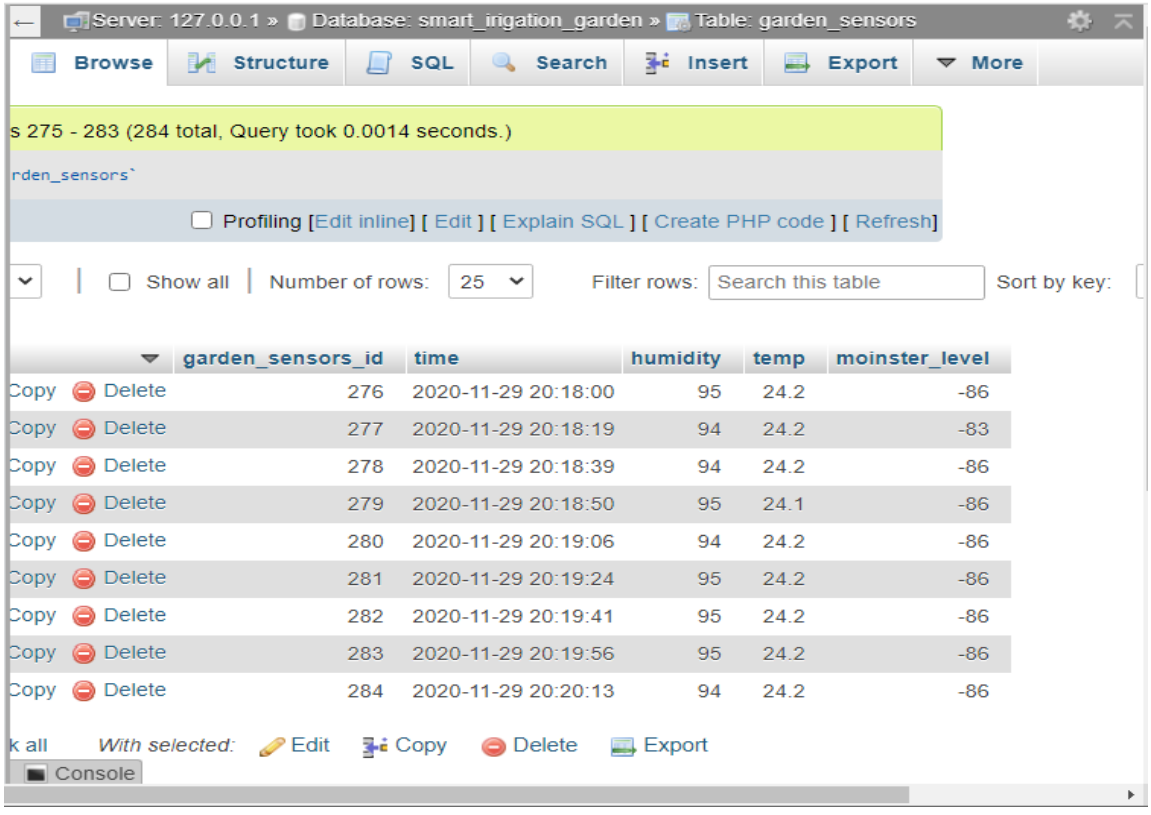


Figure 31 moisture value

5.3THE DATABASE

The data is being kept in the database of local host (Dashboard) where it is trained by ANN to get real data that is used in the garden for future to be watering.



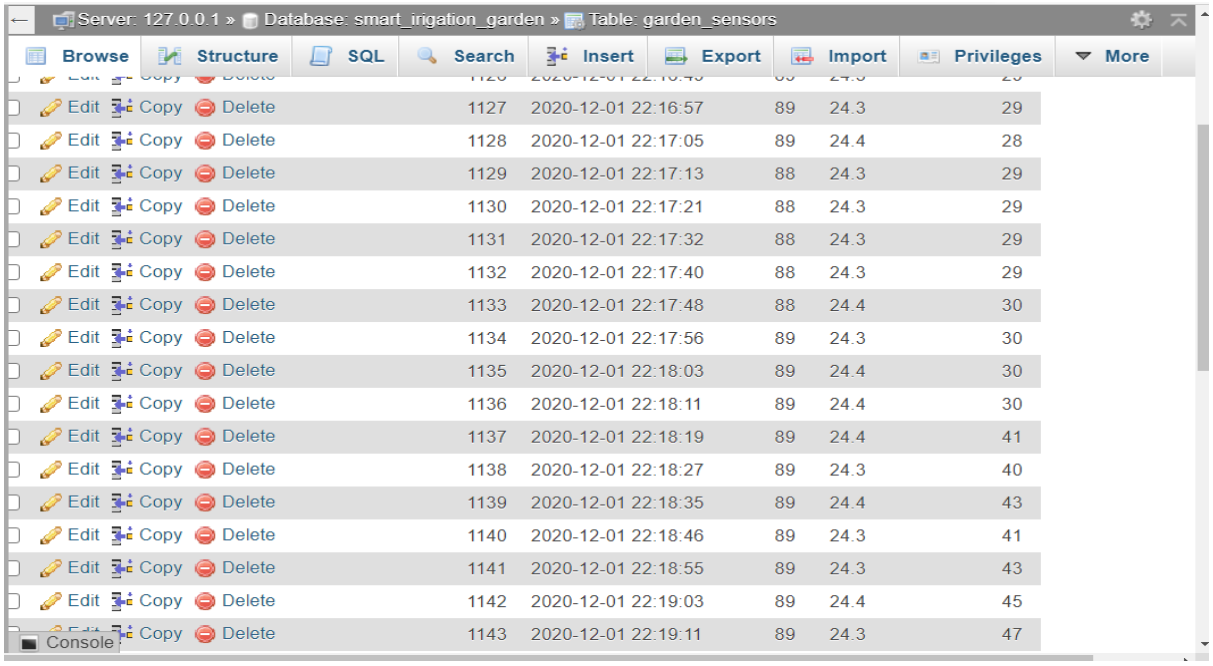


Figure 32 Database storage

5.4 System Requirement for stage of automated home garden watering system

It has functional necessities where scheme will be working through dissimilar phases and these phases are:

1. If the moisture device data is dehydrated in the garden (its sites), the scheme is chequered by data from Meteo to check rain weather if there is rain the system is not effort because no need for watering at the same time of rain, otherwise the scheme is checking the temperature sensor with humidity sensor if the temperature and portion of humidity are high then the scheme is not working because it is not the right time for watering procedure because the water is easily to evaporate.

2. If the temperature and humidity are low and there is no rain and even the moisture sensor is dry then signal is sent to the controller to open the valve and pump.

3. If water level is low in the garden then the scheme willpower off automatically and send short message services to the user, by using smart phone and for the system sated will automatically predict the real amount of water needed to water the garden.

CHAPTER SIX.

6.1 Conclusion and Recommendation

Based on comparison of experimental results, it is clear that Machine Learning Algorithm applied has played the vital role in prediction of water used in Garden using automated home garden watering scheme has been verified and sensibly good presentation is exposed based on the test outcomes. One of the chief charities of this project is the measurement of soil moisture, temperature and Humidity by use ANN to compare the data fetched from the garden with those of weather to get real data of water to be used in the future.

The system is used to reduce the water usage in residential and gardens of Kigali city as it is able to save water and spending of time during watering of garden and thus help in the management of water. It is also used to reduce water bill from WASAC, because of real quantity of water being used during watering in the garden.

The receiver acts as a water needed to be used to statistics feeder which can transfer the statistics distantly to the waiter if the processer is used as a share of receiver unit, consequently extra classy scheme can be industrialised to show and analyse period succession aquatic usage statistics, in its place of only showing the present aquatic usage statistics.

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