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On

"IoT AND WIRELESS SENSOR NETWORK (WSN) BASED DATA LOGGER SYSTEM WITH RAIN PREDICTION USING ML "

A Project report submitted in partial fulfillment of the requirements for the award of the degree of
***Bachelor of Engineering in Electronics and Communication Engineering** of*
Visvesvaraya Technological University, Belagavi

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CERTIFICATE

This is to certify that the project work entitled **"IoT AND WIRELESS SENSOR NETWORK (WSN) BASED DATA LOGGER SYSTEM WITH RAIN PREDICTION USING ML"** is carried out by **AAKARSH SATYAM (1DT18EC002), LAVANYA R (1DT18EC043), M. V. NARASIMHA PRASAD (1DT18EC047)** and **NAVEEN N. N. M (1DT18EC053),** bonafide students of **DAYANANDA SAGAR ACADEMY OF TECHNOLOGY AND MANAGEMENT** in partial fulfilment for the award of the degree of **Bachelor of Engineering in Electronics and Communication Engineering** of the **Visvesvaraya Technological University, Belagavi** during the year **2021-2022**. It is certified that all corrections/ suggestions indicated for internal assessment have been incorporated in the report deposited the departmental library. The project report has been approved as it satisfies the academic requirements with respect of project work prescribed for the award of Bachelor of Engineering Degree.

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ABSTRACT

Agriculture has been the back bone of India as it is the case with many a country. But the use of modern technology for this sector's development has been slow. To increase the availability of technology for the improvement of crop yield should be kept in mind and worked on. For ages the traditional method of farming has been the practice in India. Here, farmers have very little knowledge on rain prediction or on the change of soil fertility and other important aspects of farming. Because of this, the current trend of increase in demand for food and agricultural yield is hard to be satisfied. Hence proper research is done on various technology that can be implemented in the field of agriculture which will aim at smart farming, sending the data to cloud using IoT and Firebase, using ML algorithms to predict rain or other desired features so we can manage with limited resources and get improved crop yield while managing the limitations.

Keywords - Wireless Sensor Network, Linear Regression, Smart farming, Rain prediction.

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Chapter-1

Introduction

1.1 Background

India is set to be the most populated country within the first quarter of this century. With the huge populous comes the problem of feeding it. Agriculture is a vital part of India's economy and its backbone. Research and surveys have shown that as much as 18% of India's Gross Domestic Production is accounted by agriculture [1]. Indian agriculture provides employment to around half the country's workforce accounting for almost around 600 million people. The task of feeding the entire country and also exporting food to other countries is a tough one. This is made even riskier taking into account the lack of predictability when it comes to weather patterns due to climate change. The advancement in technology has helped many fields in the real world making the lives of entrepreneurs, workers and customers easy alike [2]. Yet the implementation of the technological marvels in the field of agriculture has been rather slow especially in India.

Wireless Sensor Network (WSN) based data logger system for collecting data accurately from agricultural field. One of the fundamental aspects that we can improve in agricultural field is by getting more data from soil, atmosphere, plants, etc accurately. By collecting more data, we can apply machine learning and prediction algorithms to figure out the amount of fertilizer, water and other manures required for crops to get better yield. But in developing countries like India, cost of the technology is quite not affordable for implementing in large scale. Hence an effective and low-cost real-time monitoring system is needed, to monitor and collect data accurately [1].

Networks of specialized, geographically scattered wireless sensors that track and record environmental physical conditions and transmit the gathered information to a central point are known as wireless sensor networks. Environmental factors like temperature, sound, pollution levels, humidity, and wind can all be measured by WSNs. Our project relies on the idea of a wireless sensor network (WSN), in which a sensor node gathers information from several sensors such as humidity, temperature, and soil moisture content.

The main activities involved are data collection, processing, and variable rate of application of inputs. We can reduce a lot of manual work in the field of agriculture using automation [3]. The major problem faced in many agricultural areas is that lack of mechanization in agricultural activities. In India, agricultural work is done by hand using traditional equipment like a sickle and a plough. Our Smart Farming System automates agricultural tasks while reducing manual labor. Because to the use of synthetic fertilizers and pesticides, the groundwater is contaminated. In smart farming, organic fertilisers like compost, animal dung, and green manure are used in their place to improve the soil's structure.

1.2 Smart Irrigation and Farming

We started to explore the recent trends in perpetration of ICT in smart husbandry ways. In the meantime, we did a brief erudite check on the published workshop of prestigious scholars in this field. A new approach for Digital Agriculture was proposed describing connections between Precision Agriculture, Digital Earth, Information Agriculture, Virtual husbandry, and Digital Agriculture. The demand to put forward the conception of Digital Agriculture was bandied. Detector data collection and irrigation control was put forward on vegetable crop using smartphone and wireless detector networks for smart husbandry. The environmental data can be collected and the irrigation system can be controlled using smartphone. A unique smart husbandry system grounded on pall computing was suggested for the early identification of tomato borer insects. Exercising IOT and pall computing, this issue is resolved. For multifunctional vehicle route control and data collection grounded on Zig- Beemulti-hop mesh network, real- time monitoring of GPS- shadowing was recommended. It condenses the section on path planning for a multipurpose vehicle.

The vehicle shadowing system communicates with one another using the ZigBee wireless network and the global positioning system(GPS). A case study pressing the operation of a variety of environmental detectors and beast monitoring systems on an experimental smart ranch as part of the Web of effects for husbandry has been proposed. A system that specifies the alert was tested in a husbandry area and the results were analyzed. The linked cell was used which allows longer- term analysis and data participating to a larger scale. From the below erudite check, we've set up a new approach using a smart seeing system that keeps track of the external environmental factors and does communication with the smart irrigator system to perform necessary tasks that are needed for husbandry. In this system, we've furnished a resolution for the problems faced by the growers. The main problems faced by them are electricity deficit, homemade labor work, lack of robotization, knowledge deficiency about husbandry, and not knowing about the acceptable operation of macro mineral contents (N, P, and K). Our system does the job of seeing and also habituates to the surroundings.

Fresh- water failure is one of the biggest problems faced by numerous nations in the world and the problem is getting adverse with time due to increase in population and hamstrung operation of fresh water. Grounded on a United Nations report, the world population (around7.6 billion presently) is anticipated to increase to8.6 billion by 2030,9.8 billion by 2050 and11.2 billion by 2100 with roughly adding 83 million people monthly. Agriculture sector attract a large quantum of water in irrigation practices [6]. In India, a water stressed nation, around 80 of brackish coffers are used in husbandry sector. The traditional irrigation ways don't use water optimally, which raises a need for perfection husbandry with smart irrigation. In recent history, the penetration of Information and Communication Technologies (ICT) has bettered significantly in pastoral areas.

1.3 Machine Learning Integration

Internet of effects (IoT) and machine literacy (ML) grounded results have a great eventuality to ameliorate the agrarian geography. The results can be used in colorful confines, e.g., smart irrigation; monitoring and control; agrarian yield and Agri- resource operation; agri- business operation. IoT technology is grounded on connecting operation specific objects (with detectors and/ or selectors) with Internet and intelligently assaying (using ML) the data entered from the objects for making perceptive opinions. The ML is a branch of Artificial Intelligence (AI), which helps machines in taking independent opinions. The smart irrigation ways have gained important attention in recent history. numerous irrigation systems are proposed grounded on wireless detectors networks (WSN), IoT and Artificial Intelligence (AI)/ ML. A smart collection of detector system for scheduling irrigation. In this system, a detector circuit board is equipped with detectors for soil humidity, thermocouples and active RFID (Radio frequency Identification) transmitter. Gutierrez proposed automated smart irrigation system. This system uses a Smartphone irrigation detector which comprises of bedded camera, photovoltaic panel, Smartphone holder, illumination pole and anti-reflective glass. Joaquin developed an automated system for irrigation using Wireless Sensor Network and mobile data (GPRS) communication

Module. Colorful machine literacy (ML) ways to develop smart model that were having capability to prognosticate daily irrigation plan by the help of agriculturist's knowledge [3].

Real time automated smart irrigation system using pall of effects and Thermal Imaging. Thermal imaging fashion is grounded on the analysis of heat hand images (infrared imaging) of the objects. The thermal imaging ways can be used in measuring colorful parameter like water stress position, irrigation distribution, factory temperature and cover temperature for agrarian/ irrigation affiliated operations. An irrigation system grounded on the threshold value of cover temperature for cotton crop was proposed and its results shown a better growth over the traditional styles. It was proposed IoT grounded smart irrigation operation system grounded on Machine literacy (ML) ways. It's an automated irrigation operation system to prognosticate unborn soil humidity of forthcoming days [7]. The system uses the field data collected via detectors placed in a field and the rainfall data from rainfall soothsaying spots. The vaticination of unborn soil humidity could be veritably helpful in effective provisioning and operation of water in irrigation.

An effective perpetration of machine literacy ways for soil humidity vaticination is a grueling and open exploration direction. This paper considers ML grounded ways for vaticination of soil humidity of forthcoming days grounded on the detectors data entered from the field and the rainfall cast information. The detectors knot stationed in the field collects data for current soil humidity, soil temperature, environmental temperature and moisture, which is used for unborn soil humidity vaticination.

Chapter-2

Literature Survey

2.1 Design and Development of Wireless Sensor Network based data logger with ESP-NOW protocol

The paper describes the agriculture is one of the most important sectors of the Indian economy, accounting for 18% of the country's Gross Domestic Product (GDP) and employing 50% of the country's workforce. The demand for food in India is rising in tandem with the country's growing population. Though AI and ML have advanced weather prediction, deploying technology for agriculture on a broader scale is extremely tough. This is primarily due to the 3C's: The cost of deploying technology, the connectivity of technology, and the complexity of technology are all factors to consider. This is based on the wireless sensor network concept, in which a sensor node collects data from various sensors such as humidity, temperature, and soil moisture content. A sink node (also known as a base station or master node) collects data from a number of similar sensor nodes and delivers it to a cloud database, where it can be displayed and analyzed for prediction or to automate and manage real-time machinery. The benefit of the device is that the sink node is unaffected by the number of sensor nodes, making it very simple to expand the type/number of sensors without modifying the sink node ESP-NOW. The data was collected from sensor node. The sensor adds timestamp to record the time at which this data was collected. Similarly, data can be received from the rest of the nodes and can be sent to the master node. The firmware developed has very dynamic nature of adjusting to multiple nodes.

As the number of nodes in hardware grows or addition of different sensors in the existing sensor node can be handled by the master node with very little or almost no changes to be made in the firmware. Accessing the data by the user is also very flexible as Firebase Hosting is used, which can be accessed all over the world. Conclusion can be drawn that advancement in the field of agriculture is not only vital with India’s growing population but is also long overdue. Hence our system aims at monitoring and collecting data accurately which can be further subjected to any form of AI or ML algorithms to make use of the collected data. By using Wireless Sensor Network (WSN) based data logger system with

ESP-NOW protocol our project was able to collect data in a dynamic and flexible way. This project is not only efficient but also quite practical.

2.2 Smart farming system using sensors for agricultural task automation

This paper describes an investigation of contemporary trends in the use of ICT in smart farming approaches. It also describes a novel approach including a smart sensing system that monitors external environmental conditions and communicates with a smart irrigation system to accomplish important farming operations. It provides a solution to the farmers' problems with this approach. Two modules are employed: a smart farm sensing system and a movable smart irrigation system that travels along a mechanical bridge slider. Microcontrollers, sensors, and a GSM module are used in both systems to communicate with each other and with the outside world. The soil Moisture sensor in the smart farm sensing system detects the moisture content. Smart sensing technology produces precise findings, and Smart irrigator system sprays the required nutrients in accordance with the crops' needs.

The irrigator system sprinkled an adequate amount of water based on the soil moisture content data. In India 70% of its population earns it livelihood from agriculture. The inordinate majority contributes only 18% of the GDP. The key reason for this deprived performance is lack of agricultural task automation. Our Smart sensing system provides precise results and the Smart irrigator system manages to spray the necessary nutrients according to the requirements of the crops. Based on the moisture content results of the soil, adequate amount of water was sprinkled by the irrigator system. We are developing a user-friendly smart farming system which will liberate agricultural productive force greatly, change the mode of production, and realize a qualitative leap in agricultural activity.

2.3 Machine Learning based soil moisture prediction for Internet of Things based Smart Irrigation System

This paper states that the biggest disadvantage is the whole of the agricultural yield depends upon the weather; which is too big a risk to take. This is can be helped by using smart agricultural system. Smart Irrigation system basically refers to watering the crops in agricultural field based on the data obtained. The traditional method of predicting the amount of water required is discarded here. The data collected speaks for the accurate amount of water required. This is shown to produce increased efficiency. Smart irrigation system becomes necessary as crop yield can be increased and watering the plants plays a major role in it. This can be achieved by the collected data. Soil moisture is predicted in this paper based on the soil moisture content collected. This is done using capacitive soil moisture sensor. To optimize the water usage in irrigation an IoT and ML based approach is presented in this paper.

As the soil moisture plays the critical role in measuring optimum water usage in irrigation, the ML techniques are used for prediction of soil moisture of upcoming days based on the sensors' data collected from the field and the weather forecast information. The results are analysed for multiple ML techniques and the results of GBRT based approach are very encouraging. Such kind of techniques could help in achieving optimum utilization of precious fresh water resources in irrigation, which is a need of the hour in many waters stressed countries like India.

2.4 Improved the efficiency of IoT in agriculture by introduction optimum energy harvesting in WSN

This paper describes Internet of Things as the most effective study topic because sensor nodes and smart devices can collect data from many sources and communicate it with a server without the need for human intervention. Wireless sensor networks, in which data is shared and communicated with the use of sensor nodes, are the most essential idea in IoT. These sensor nodes are dispersed at random over the defined area in order to collect and sense data on various characteristics. We apply the concept of energy harvesting because sensor nodes have limited energy or backup power. These solar-powered sensor nodes will be used to track crop management, water management, pesticide monitoring, and climate change. In this study, an Internet of Things (IoT) based wireless sensor system is developed, which employs the notion of energy harvesting in agriculture to build, monitor, and control the system's growth and productivity. This paper presents the Internet of things-based agriculture system using the concept of the wireless sensor network. With the help of this system crop management, temperature monitoring, humidity controlling, etc. became more efficient because farmer can schedule all upcoming task and events on the system, if there is any issue like temperature or water, sensors can sense the data immediately and passes this information to the server so that the system can manage scheduled events according to the collected information. One main issue in this system is the limited battery power of sensor nodes so here author use the concept of energy harvesting through solar energy; it is a wide source of energy from the environment. To utilize this energy in smart agriculture with the help of IoT and WSN technologies produce successful results in the field of agriculture.

2.5 Modern Agriculture Using Wireless Sensor Network (WSN)

Here, it is explained how the WSN assists the farmer in producing a large quantity of crop while lowering the yield cost. Climate change, environmental change, and natural disasters all have an impact on agriculture. Soil and water management can be done with WSN. Because wireless sensors are employed, the implementation costs are very inexpensive. Wireless sensor nodes are employed to monitor the crops in this paper. Sensors can be used to detect temperature, humidity, and other types of theft. This aids in increasing agricultural productivity. Agriculture is a vital source of food for all living beings. However, various environmental changes are affecting agriculture crops nowadays. In order to overcome this, WSN plays a vital role in agriculture. WSN is used in agriculture for monitoring, temperature measurement, irrigation system monitoring, water supply monitoring, and so on. WSN assists the farmer in producing a large quantity of crop while lowering the yield cost. The smart farm helps the farmer to yield high profit by growing the crop without infection and at exact soil moisture content. Due to automatic process, it reduces the human effort and view the growth of crop through smart phone.

The wireless communication reduces the cost of implementation. In future this is implemented for large area of land. The internet connectivity is required at all the time to communicate the data to farmer. The predefined prediction of weather condition helps the farmer to cultivate the crop based on weather condition. Agriculture can be done in this modern world using many latest technologies. The farmer can operate mobile phones from anywhere at any time. This application can group many farmers into it and also the specialist. This is more suitable for agriculture dependent countries like India.

2.6 Rainfall Prediction using Multiple Linear Regressions Model

The paper describes how Machine learning approaches are thought to be accurate and have been widely employed as a substitute for traditional weather forecast methods. The rate of rainfall is one of the most important aspects of the weather system, since it has a direct impact on the agricultural and biological sectors. The goal of this study is to create a multivariate linear regression model that can predict the rate of precipitation (PRCP), or rainfall rate. In this paper, authors have used multiple linear regression model to predict the rate of precipitation (i.e., rainfall rate) for Khartoum state, based on some weather parameters taken as the independent variables Those weather parameters are the mean temperature, maximum temperature, minimum temperature, Dewpoint, sea level pressure, station pressure, mean visibility and wind speed.

It was found that obtained results show that the mean square error between actual and predicted values of the rainfall precipitation rate (PRCP) has been significantly decreased during testing time. It has been found to be 85% when the amount of test data equals the amount of training data and 59% when more test data is used. Explanation of this reduction needs supplementary research. For example, it may indicate that the model used needs more data in the training phase.

2.7 Prediction of Climate Variable using Multiple Linear Regression

This paper describes the issue of comprehending and predicting these climate occurrences could be caused by changes in global temperatures, natural disasters in the last three years, rising sea levels, and shrinking Polar Regions. Prediction is crucial, and they can be run and simulated as computer models to forecast climatic variables such as temperature, precipitation, and rainfall. This study discusses the use of multiple linear regressions to estimate or predict rainfall. It can assist farmers in making proper crop production decisions. In comparison to basic linear regression, the experiment and our multiple linear regression methodology exploit the right results for rain fall. The concept of regression can be implemented by calculating coefficient, slope and the considered climate data set either day, monthly or annual wise. As well as the performance of predicting the future values can be calculated by using multiple linear regression algorithms. The natural incidents may not possible to stop and cannot estimate in a efficient and accurate manner. In general by using the concept of future estimation concept or events or values there may be a scope to minimize lot of problems. In this project we have implemented the simple regression methodology, multiple regression and we predicted the values, the multiple regression error rate also less when comparing with simple linear regression.

Finally concluding that multiple linear regressions can be better than simple linear regression. By considering vapour pressure value as a dependent variable with other values as independent we successfully implemented the simple linear regression method multiple linear regression. This is the concept of prediction but not in a accurate manner because we know that climate factors changes due to different reasons and impacts on it.

2.8 Comparative Study of Regression Models Towards Performance Estimation in Soil Moisture Prediction

In this paper the result of experimental scenario for different machine learning regression techniques to predict the soil moisture. Soil moisture is an important part of the hydro-logical system since it depicts the normal conditions in a small volume of soil. It is critical to build an effective irrigation management system for this reason since an accurate prediction of soil moisture can save water and energy. They have employed supervised machine learning algorithms to forecast soil moisture. A training data set is used to train the algorithm in supervised learning, and then testing and validation data sets are used to test the taught system. Regression models are a method that involves a targeted variable that must be predicted from a set of known predictors.

Multiple linear regression is a statistical analysis algorithm for determining a link between multiple independent variables and a dependent variable. This algorithm they've used can help us in implementing a similar algorithm in our project. Once the relationship between the independent and dependent variables is established, all information about the independent variables may be obtained and used to make more accurate and influential predictions about the effects. Furthermore, this research examines various machine learning regression algorithms.

2.9 Crop Water Requirement Prediction in Automated Drip Irrigation System using ML and IoT

This research paper proposes to automate the time-consuming process by developing a microcontroller-based system for automatic smart drip irrigation that can accurately forecast the amount of water required by the crop. With the use of sensors, the amount of water that should flow through drip irrigation will be predicted by taking into account the weather, soil, and crop conditions. The goal of this research is to determine the exact amount of water that needs to be delivered to the crops. Water is usually delivered to the crop when the conditions sensed by the system achieve the targeted conditions, and therefore water is given at such intervals in many techniques. The system, according to this proposal, first detects meteorological conditions and soil moisture using sensors such the soil moisture sensor and the DHT11 sensor. The data from these sensors is then sent to the Arduino Nano via serial communication. The ML code is executed on the Arduino Nano, which is connected to the local machine, and these sensor inputs are used as input parameters. The output is monitored when the code has been computed. The technologies used in this paper simulate how the system forecasts the required amount of water for irrigation of each crop by taking into factors like weather, soil and crop conditions.

When there is a lot of data and a lot of dependencies, machine learning is applied. The available facts must be used to make an accurate prediction. Moisture and temperature are important factors in deciding the amount of water that should be applied to the soil in this suggested system. In this proposed system there is moisture and temperature which play a crucial part in determining the water content that has to given to the soil. These parameters are measured along with soil moisture to predict an accurate output. Finally, in conclusion with this proposed system one can save manpower and water required to improve crop production which in the longer run increases the profit.

2.10 AI and IoT Based Monitoring System for Increasing the Yield in Crop Production

Research is performed on a marigold plant to help detect and predict the most suitable conditions for optimum growth in this paper. Plant growth is monitored using an IoT-based monitoring system that measures humidity, temperature, soil temperature and moisture, and light intensity. Different sensors units, such as DHT11, LDR, DS18B20, Soil Moisture sensors, Noir camera, single-board micro-controllers, and Application Programming Interfaces, are used to collect data for plant growth. Different Machine Learning (ML) algorithms are used to further analyze the retrieved parameters. The top methods for analyzing physical characteristics responsible for marigold plant growth were found to be Logistic Regression, Gradient Boosting Classifier, and Linear Support Vector Classifier (SVC). This paper provides sufficient information on the kind of sensors, hardware technologies and also software algorithms to be used in a project of similar calibre. By using data visualization, this study discovered the most beneficial settings for the marigold plant, and this trained model can then be used to identify the rate of growth of the marigold plant by simply providing it with the necessary environmental physical conditions. In the realm of artificial farming, this technology offers a lot of potential. All the sensors have been deployed in the field and scripted using C++ in Arduino IDE. Json script is used to maintain the serial communication between Arduino Uno and Esp8266 Wi-Fi module. We have found the best favourable conditions for the marigold plant by data visualization and later on, this trained model can be used to detect the rate of growth of marigold plant just supplying it the environmental physical conditions.

Further, Logistic Regression, Linear SVC and Gradient Boosting Classifier found to be the best fit algorithms with 83.33% accuracy. This technique has a great scope in the field of artificial farming. Not only we can detect the best favourable conditions for particular crops like millet, chillies, tea, coffee etc., but also we could prepare a dataset using IoT which could tell us the best suitable plant for a particular soil and climatic condition.

Chapter-3

Problem Statement

Since our project is concerned with the field of agriculture, our solutions to the problems cannot be too expensive and cumbersome to use. Using small but smart devices that can communicate with each other and work in synergy is the goal of the Internet of Things (IoF). Machine learning is the best way to work towards complex issues while using the least amount of code and computing power. Hence, we will be using a combination of internet of things and machine learning to develop a low cost and effective real time monitoring system. Since weather patterns can change within an instant, we have to use technology that can collect data at regular and store it and also compute it in real time [1]. Certain crops are quite sensitive; hence irrigation has to be carried out in a precise manner. This means using technology to gather information about the environment and then deciding how much water the cross need at the time. Some crops can be destroyed if they are watered extensively. To ensure this does not happen, we must adopt a way to predict if there will be rain and to what extent. This will help the farmers gauge what the irrigation situation will be in the future which in turn lead to better yield and harvest of the crop.

Chapter-4

Objectives

The first object of the project is to collect data. This is a vital step as the rest of the processes depend on reliable data. This has to be done with less hardware. Implementation of this project will be done in agricultural fields so the farmers must not feel it is too complicated to work with. This hardware must also produce as close to zero errors, if not then whole harvests will be destroyed due to these errors. Hence this system must be effective at doing its job. The hardware components and the whole system itself will be low cost so as to not over burden the farmers. The hardware part of the project will mainly contain sensors that will be used as the monitoring system. This data collected from the sensors has to be sent wirelessly hence Wireless Sensor Network (WSN) will be used. The sponsor that will be used will be able to collect data like humidity, temperature, soil moisture, etc. Farmers can add more sensors that can capture other data as per their needs. To compute all this data, we will use Linear Regression. These algorithms will help with the prediction of rain. Depending on the farmer's needs, actuators can be used to perform certain actions based on the results received from the system.

Chapter-5

Methodology

5.1 Design Goals

The following are the design goals that are applicable to every application regardless of application domain, size or complexity. None the less, this project focuses on the following points for design goals

- Simplicity as in UX/UI interface
- Reliable data collection
- Environment adaptable
- Flexibility in Sensor node
- Optimizing the sensor node
- Ease of addition of sensor nodes
- Storage of data safely
- Ease access of data from anywhere in the world

5.2 Approach

The total system is divided into 4 modules – Composing sensor nodes and data collection, creating sink node and master node and establishing communication between them, creating cloud storage and sending the data to cloud storage, finally battery management circuit for all sensor nodes

1. Composing sensor nodes and data collection

- Sensor node is composed of sensors like soil moisture sensor, temperature and humidity sensor, rain sensor, etc.
- This is collected by a microcontroller called NodeMCU
- The protocol used between them is one wire protocol

2. Creating sink node and master node and establishing communication between them

- A sink node acts as a gateway. It collects data from sensor nodes using ESPNOW protocol and pushes it to master node
- Sink node is composed of ESP8266

- The master node is composed of ESP32 and collects the data from sink node using UART protocol and sends it to Cloud storage using HTTP protocol

3. Creating cloud storage and sending the data to cloud storage

- The cloud storage used is from google called “Firebase Real-time database”
- It collects the data from Master node and stores it safely
- It also displays the data in real-time and can be accessed from anywhere in the world

4. Battery management system for sensor nodes

- Lithium-ion batteries of 3.7V, 2200mAh is used to power the sensor nodes
- TP4056 is used to charge the batteries

5.3 Software Architecture

Following are the software requirements for the proposed design:

5.3.1 Arduino IDE

Arduino is an establishment that creates and produces single- board microcontrollers and microcontroller accoutrements for creating digital bias. It's an open- source tackle and software action. Its software is distributed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), allowing anybody to produce Arduino boards and distribute the software. Java was used to produce the cross-platform Arduino IDE, which is available for Microsoft Windows, macOS, and Linux. It has a law editor with tools for textbook copying and pasting, textbook relief, automated indenting, brace matching, and syntax pressing. It also offers straightforward one- click collecting and uploading tools for Arduino systems.

Figure 5.1: Arduino IDE Logo

5.3.2 Firebase

Firebase is a platform developed by Google to make mobile and web operations. Save the data and attend it with the NoSQL pall database. Data is synced in real time across all guests and is available indeed when the app is offline. The data is stored as JSON and accompanied in real time with each connected customer. When you make a cross-platform app using the Apple platform, Android, and JavaScript SDK, all guests partake a Realtime Database case and automatically admit updates for the rearmost data. Because real- time databases are NoSQL databases, they've different optimizations and features than relational databases. The Realtime Database API is designed to allow only operations that can be performed snappily [17].

Figure 5.2: Firebase Logo

5.3.2 Python Libraries

NumPy, which stands for Numerical Python, is a library conforming of multidimensional array objects and a collection of routines for recovering those arrays. Using NumPy, fine and logical operations on arrays can be performed. It's a library conforming of multidimensional array objects and a collection of routines for processing of array.

Pandas is an open- source Python Library furnishing high- performance data manipulation and analysis tool using its important data structures. In 2008, inventor Wes McKinney started developing pandas when in need of high performance, flexible tool for analysis of data. Using Pandas, we can negotiate five typical ways in the processing and analysis of data, anyhow of the origin of data — cargo, prepare, manipulate, model, and dissect. Python with Pandas is used in a wide range of fields including academic and marketable disciplines including finance, economics, Statistics, analytics, etc.

Matplotlib is one of the most popular Python packages used for data visualization. It's a cross-platform library for making 2D plots from data in arrays. Matplotlib is written in Python and makes use of NumPy, the numerical mathematics extension of Python. It provides an object- acquainted API that helps in bedding plots in operations using Python GUI toolkits. Matplotlib along with NumPy can be considered as the open-source fellow of MATLAB.

Scikit-learn (Sklearn) is the most useful and robust library for machine learning in Python. It provides a selection of efficient tools for machine learning and statistical modeling including classification, regression, clustering and dimensionality reduction via a consistence interface in Python. This library, which is largely written in Python, is built upon NumPy, SciPy and Matplotlib.

5.4 Hardware Architecture

Following are the hardware requirements for the proposed design:

5.4.1 NodeMCU (ESP8266) (as Sensor Node and Master Node)

NodeMCU is an open- source firmware with open- source prototyping board designs. The name "NodeMCU" is a combination of the word's" knot" and" MCU"(micro-controller unit).

The Lua scripting language is used in the firmware. The firmware is erected on the EspressifNon-OS SDK for ESP8266 and is grounded on the eLua design. It makes expansive use of open- source systems similar as lua- cjson and SPIFFS. druggies must elect the modules applicable to their design and make firmware acclimatized to their requirements due to resource constraints.

Figure 5.3: NodeMCU-ES8266 module

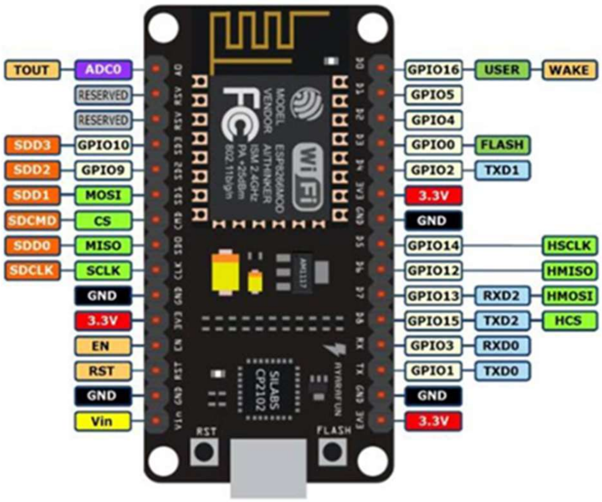


Figure 5.4: NodeMCU-ESP8266-Pinout

I/O index	ESP8266 pin
0 [*]	GPIO16
1	GPIO5
2	GPIO4
3	GPIO0
4	GPIO2
5	GPIO14
6	GPIO12
7	GPIO13
8	GPIO15
9	GPIO3
10	GPIO1
11	GPIO9
12	GPIO10

Figure 5.5: NodeMCU-ES8266-Pin Functions

A circuit board configured as a binary in- line package that integrates a USB regulator with a lower face- mounted board containing the MCU and antenna is generally used for prototyping. The design was originally grounded on the ESP8266's ESP- 12 module, which is a Wi- Fi SoC integrated with a Tensilica Xtensa LX106 core, which is extensively used in IoT operations.

5.4.2 • ESP32 (As Sink Node)

ESP32 is a low- cost, low- power system- on-a-chip microcontroller family with erected- in Wi- Fi and binary- mode Bluetooth. The ESP32 series is powered by a Tensilica Xtensa LX6 binary- core or single- core microprocessor, a Tensilica Xtensa LX7 binary- core or a single- core RISC- V microprocessor, and includes erected- in antenna switches, RF balun, power amplifier, low- noise admit amplifier, pollutants, and power- operation modules. Espressif Systems, a Shanghai- grounded Chinese company, created and developed the ESP32, which is manufactured by TSMC using their 40 nm process. It's the ESP8266 microcontroller's successor [15].

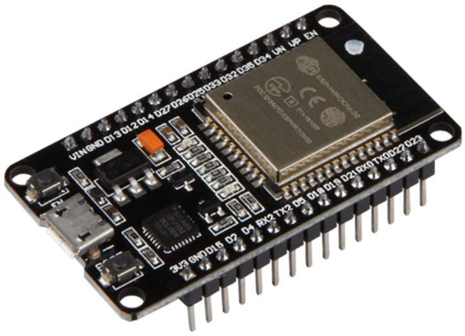


Figure 5.6: ESP32 Module

5.4.3 Temperature and Humidity - DHT11 Sensor

The DHT- 11 Digital Temperature and moisture Detector is a simple and affordable digital temperature and moisture detector. It measures the girding air with a capacitive moisture detector and a thermistor and labors a digital signal on the data leg (no analogue input legs demanded). The power force for the DHT11 is 3-5.5 V DC. When the detector is powered up, don't shoot any instructions to it within one second in order to pass the unstable status. For power filtering, connect a 100nF capacitor between VDD and GND.

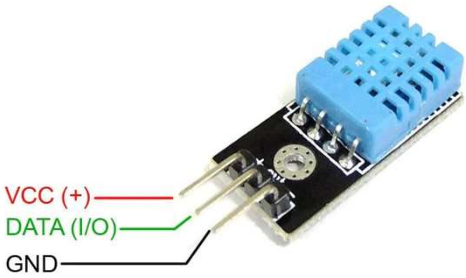


Figure 5.7: DHT11 Sensor

TABLE I: PINOUT OF DHT11 SENSOR

VCC	DC Pin (3.3V – 5V)
Data	Outputs both Temperature and Humidity through serial Data
GND	Ground Pin

5.4.4 Rain sensor

Rain sensors are a type of switching device used to detect precipitation. It acts like a switch, and the principle of operation of this sensor is that the switch normally closes when it rains. Basically, this board contains a nickel-plated line and operates according to the resistance principle. This sensor module enables humidity measurement via analog output pins and provides digital output when the humidity threshold is exceeded.

Figure 5.8: Rain Sensor Module

Here, PCBs are used to collect raindrops. When it rains on the board, it creates a parallel resistance path calculated by the op amp. This sensor is a resistance dipole and only shows resistance based on humidity. For example, when it dries, it has higher resistance, and when it gets wet, it has less resistance.

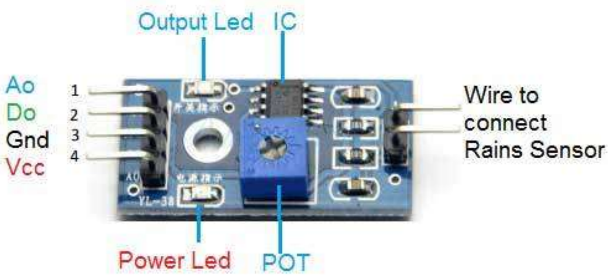


Figure 5.9: Rain Sensor Module control

TABLE II: PINOUT OF RAIN SENSOR

AO	Analog Output Pin
DO	Low/High Output Pin
GND	Ground Pin
VCC	5V DC Pin

5.4.5 Soil Moisture Sensor

The mechanism of the soil moisture sensor is very simple. A bifurcated probe with two exposed conductors acts as a variable resistor whose resistance changes depending on the water content of the soil. This resistance is inversely proportional to the water content of the soil.

A typical soil moisture sensor consists of two components.

1. Probe: The sensor contains a bifurcated probe with two exposed conductors that are inserted on the ground or elsewhere to measure moisture content. As already mentioned, it acts as a variable resistor whose resistance changes with soil moisture.
2. Module: The sensor also includes an electronic module. The module produces an output voltage depending on the resistance of the probe and can be used with the AO pins. The same signal is sent to the LM393 precision comparator, digitized and made available on the DO pin.

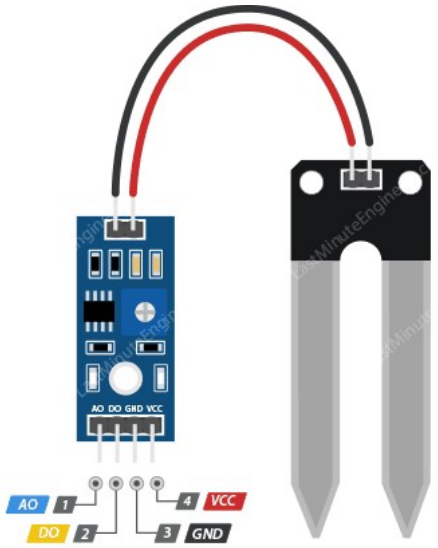


Figure 5.10: Soil Moisture Sensor Module

TABLE III: PINOUT OF SOIL MOISTURE SENSOR

AO	Analog Output Pin (Analog signal between the supply value to 0V)
DO	Digital Output Pin (Digital output of internal comparator circuit)
GND	Ground Pin
VCC	DC Pin (3.3V – 5V)

5.5 System Architecture

System Architecture is a conceptual model that defines the structure, behaviour, and more views of the system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviour of the system.

5.5.1 Functional Block Diagram

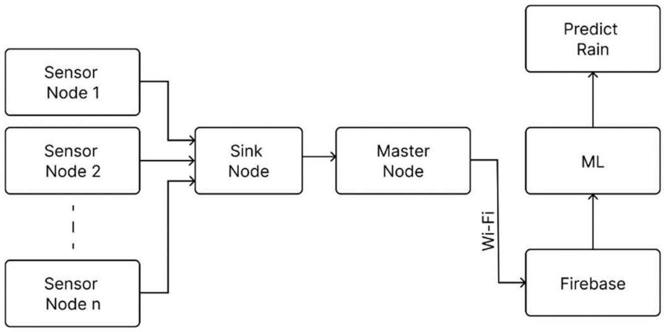


Figure 5.11: Block Diagram of Proposed Design

Our project works on a wireless sensor network (WSN), in which a sensor node gathers information from several sensors such as humidity, temperature, and soil moisture content. A sink node, also known as a base station or master node, gathers data from several similar sensor nodes and delivers it to a cloud database where it may be analysed and displayed to make predictions or automate and manage real-time machinery.

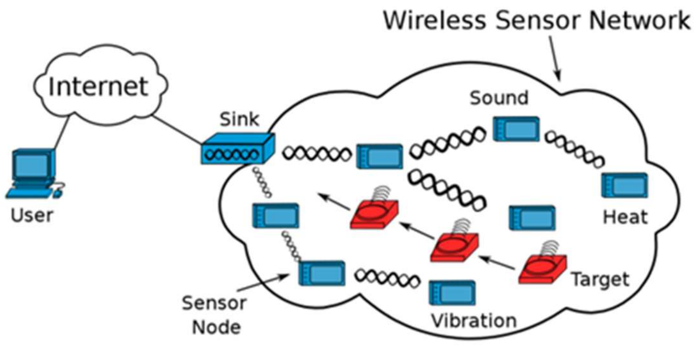


Figure 5.12: Block Diagram of WSN network

To interact with users through the internet, a sensor node made up of several sensors is linked to a sink node. Our technology has the advantage that the sink node is not reliant on the quantity of sensor nodes, making it simple to expand the kind or number of sensors without altering the sink node. For the communication portion, there is a proprietary protocol called ESP-NOW which is based on IEEE 802.11 vendor-specific action frames. The sensor node may become inactive once the data has been transferred from it. The data transfer operation will repeat once the user-specified time interval has passed. With this protocol, the sensor node uses just 170mA while transmitting data and 80mA when it is idle.

The sink node is made up of a master receiver (NodeMCU), which collects data from sensor nodes and transmits it via UART to an ESP8266-01 Wi-Fi module, which then sends the data to the internet. Having these two distinct systems has the benefit of keeping the system very modular. The master receiver may still receive data from the sensor node without any change if this WSN-based data logger has to be put in a remote location without access to the internet. We send the information to a local server for the needed calculation on-site and display the real-time data to the user over a local network.

As shown in the block diagram figure, the overview of the circuit diagram of WSN based data logger system. Our sensor nodes consist of three sensors and a microcontroller. A single battery is used to power the circuit. Although sensor node can contain any sensor the user wishes, we have used DHT11 sensor, rain sensor and resistive moisture sensor.

5.5.2 Circuit Diagram

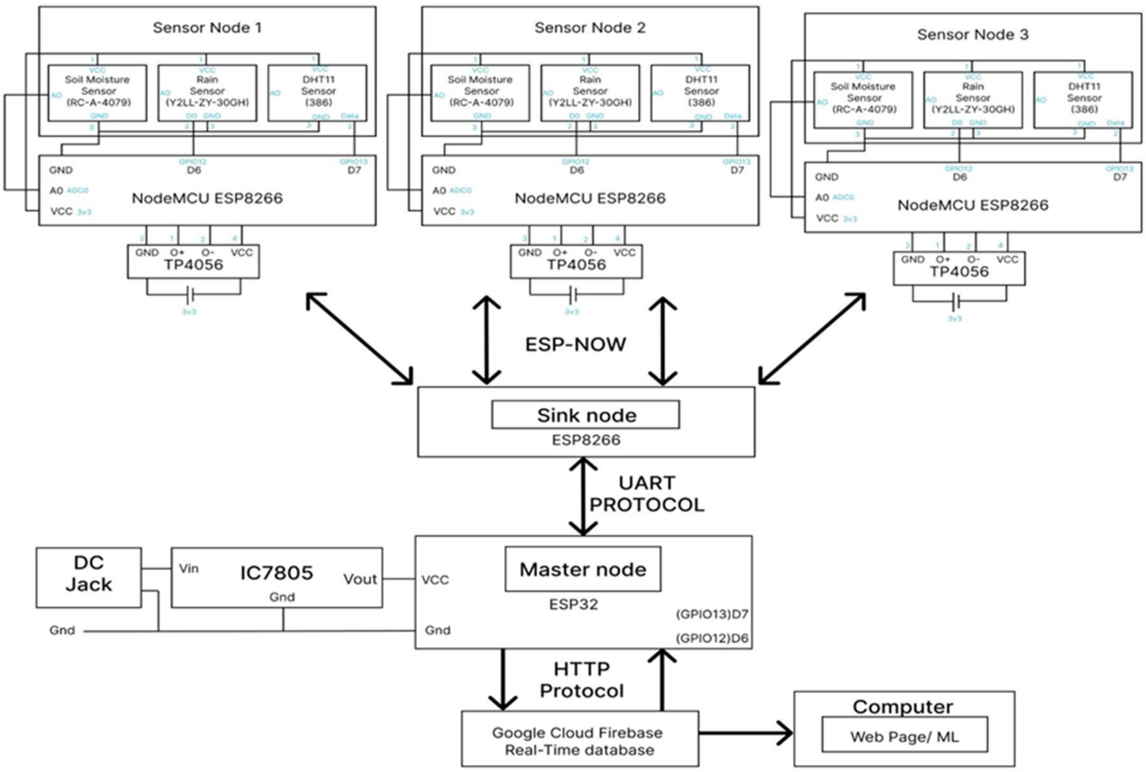


Figure 5.13: Circuit Diagram of Proposed System

The circuit diagram is as shown in the figure above. It consists of all the necessary elements depicted along with their pin numbers and connections. Figure shows three sensor nodes each equipped with the set of necessary sensors and the nodeMCU for transmission of the data. The sensor data is then sent to the sink node wirelessly using the ESP-NOW protocol. The sink node acts as a gateway, collecting all the data from all the sensor nodes and sending it to the master node using the UART protocol. The master node is configured to relay this data to the cloud database using HTTP protocol. The database used is Google Firebase. Using the database, we can access the data through any computer and run ML algorithms to predict of there is rain in the near future.

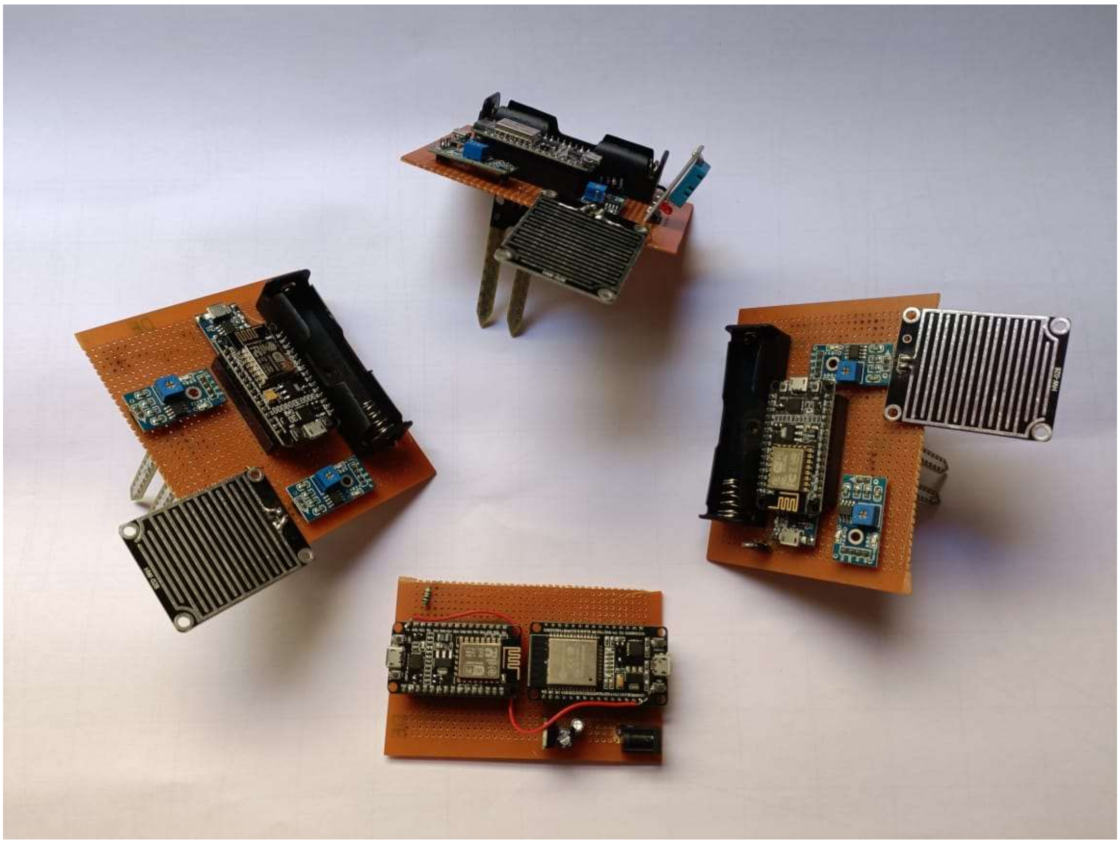


Figure 5.14: Proposed Model

5.5.3 Pins Used

The pins used in various sensors and in microcontrollers are as indicated in the table below. It shows where we are supposed to make connections for the proposed system to work. They are important part of any project. They also indicate the physical or hardware connections of any project. If anything is not working according to expectation, this is the primary inspection for debugging. Wrong physical or hardware connections might even damage the components used. Following the pins used:

TABLE IV: PINS USED TO INTERFACE THE COMPONENTS

Sensor Node:	Pins used
Soil Moisture sensor	A0, GND, VCC
Rain sensor	D0, GND, VCC
Temperature and humidity sensor (DHT11)	Data, GND, VCC
NodeMCU (ESP8266)	GND, VCC, A0, D6, D7
TP4056	GND, VCC, 0+, 0-
Sink Node (ESP8266)	D6, D7, VCC, GND
Master Node (ESP32)	D6, D7, VCC, GND

5.6 System Implementation

The basic flow of the system implementation is as written below. It simplifies the complex method of implementing system to few steps. Where, one step taken at a time can impact the outcome. This flow can be modified according to need as well.

Step1: Start

Step2: Collect data from sensors and send to the microcontroller on the sensor node

Step3: That microcontroller sends the data to sink node

Step4: Sink node collects data and pushes the data to master node

Step5: Master node sends the data to Google Firebase, Real-time database

Step6: ML algorithm is used to predict rain by using these data set values

Step7: ML algorithm predicts weather there will be rainfall or not

Step8: Stop

Step9: End.

5.6.1 Working

Sensor Node:

Sensor nodes are the ones which contain sensors that the farmer needs to collect data from agricultural field. These sensor nodes are more in number and are placed at the required distance. It is composed of Sensors like soil moisture sensor, temperature and humidity sensor, rain sensor, etc. they are collecting data using a protocol called "One wire protocol". It works very similar to I2C protocol but it is simpler to use.

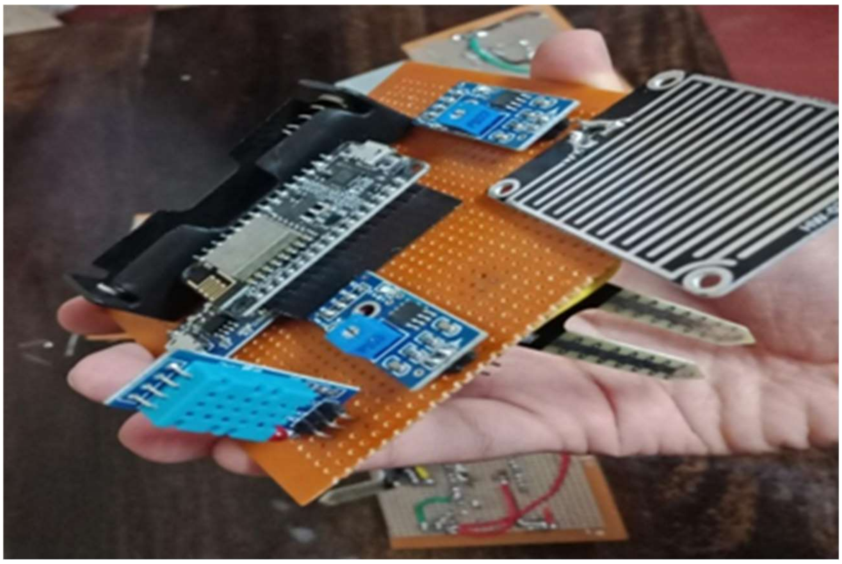


Figure 5.15: Sensor Node of the WSN data logger system

These sensor nodes have a microcontroller which is used to collect data from sensors and send it to the sink node. This microcontroller is NodeMCU or ESP8266. They can be operated by AC power source and by batteries.

Sink node:

The function of sink node is basically to collect the data from all the sensor nodes connected and send it to master node. The sink node is collecting all the data from sensor nodes using ESP-NOW protocol. Because the ESP NOW protocol only functions amongst the family of ESP created by Espressif, NodeMCU is utilised as a microcontroller. The ESP8266-01 is used in conjunction with the microcontroller to transport the acquired data from the microcontroller to the firebase database. Although NodeMCU has integrated Wi-Fi, we still utilise an external Wi-Fi module since we can quickly convert to other communication types [GPS, LORA, ZIGBEE, etc.] because we employed UART connection between the microcontroller and the Wi-Fi module in the event that Wi-Fi communication is not available.

Master Node:

The master node contains ESP32 and its function is to collect data from Sink Node using UART protocol and to send the same data to a cloud storage using HTTP protocol. The sink node and the master node are physically connected using the Rx and Tx pins and hence, they are together.

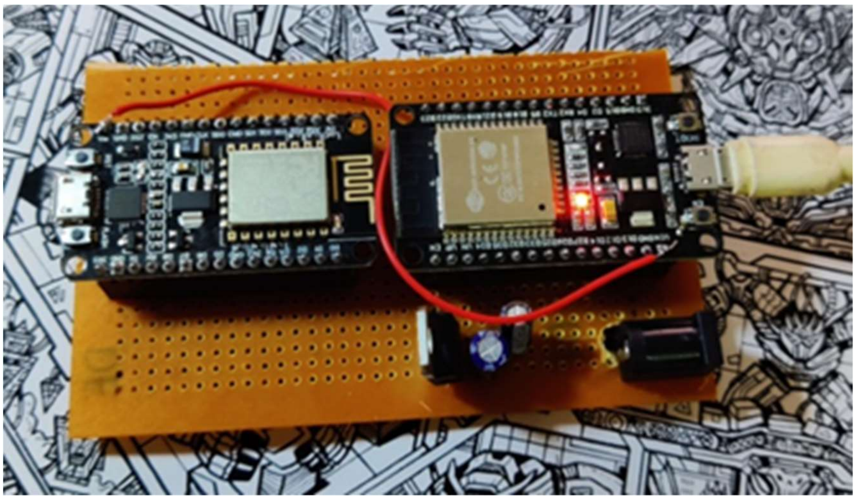


Figure 5.16: Sink Node and Master Node

As shown in the figure, the sink node and master node are physically together and their function is to collect data from sensor node and to send it to cloud storage, Firebase from Google. A sensor node may be designed to provide data at any interval, and because the master is always powered, it can receive data from any sensor node at any time.

Cloud database for data storage

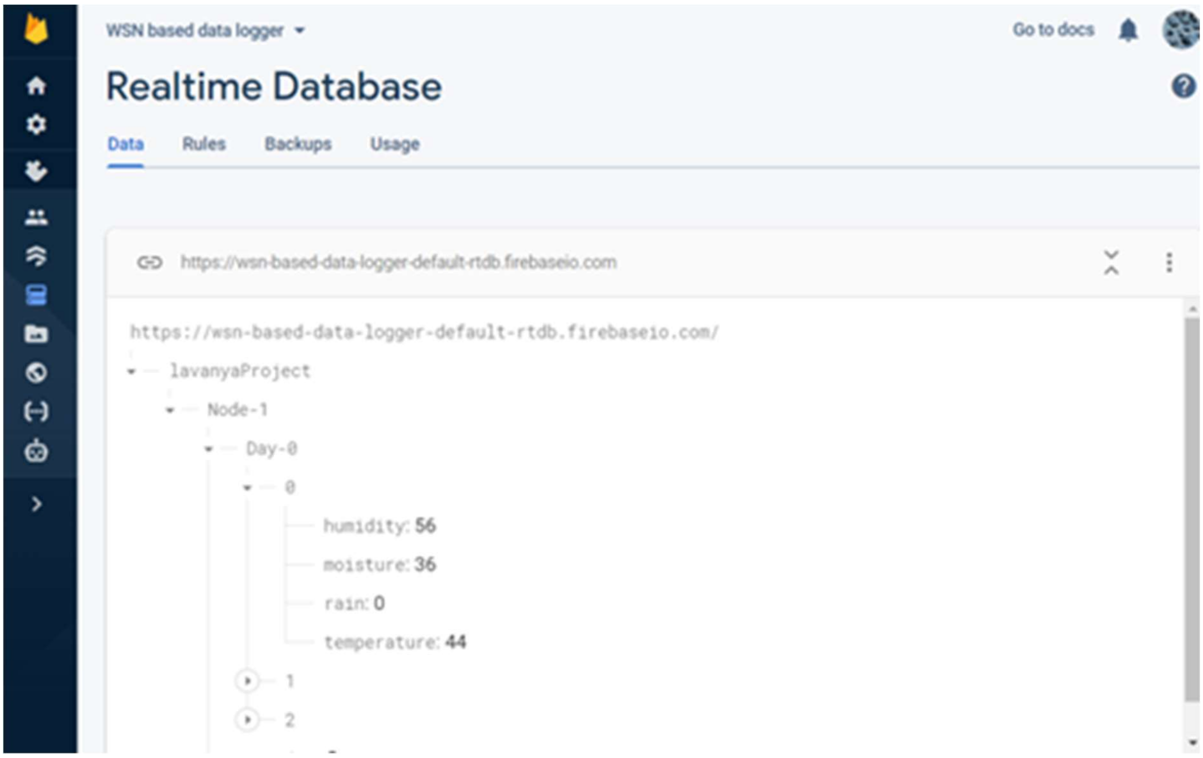


Figure 5.17: Snapshot of cloud storage showing the data in real-time

The data collected has to be stored to do any further analysis with it. For storage, we have used could storage. This has many advantages like it can be accessible all the time; it can be accessed from anywhere, etc. Firebase, a google cloud data storage provides data storage facilities along with further expansion into running AI/ML algorithms to it. It also provides real time viewing of data collected.

This is a service provided by Google to collect, store and monitor data. Google has created a platform called Firebase for building mobile and web applications [7]. Since Firebase makes it simpler to host websites and create mobile applications using an existing database, it was picked.

The user may easily and securely log in using their email to access their statistics thanks to Firebase Authentication. This is also readily expandable to support additional login ways, such as Facebook, phone, or any other. The data stream originating from the sensors is kept in a real-time database. Any change in the data will be immediately displayed on the dashboard because the database is real-time.

5.6.2 Dataset

The dataset in which ML algorithm will be performed is collected from a third-party website i.e., Kaggle. The dataset shown in below figure has many fields. The dataset is structured and labelled which clearly indicates that the type of Machine learning is Supervised learning.

1	TempAvgF	S0ilMoisture	HumidityAvgPercent	SeaLevelPressureAvgInches	VisibilityAvgMiles	WindAvgMPH	PrecipitationSumInches
2	60	49	75	29.68	7	4	0.46
3	48	36	68	30.13	10	6	0
4	45	27	52	30.49	10	3	0
5	46	28	56	30.45	10	4	0
6	50	40	71	30.33	10	2	0
7	48	36	63	30.4	9	3	0
8	53	39	65	30.39	9	1	0
9	51	39	64	30.17	10	2	0
10	50	41	76	30.1	10	5	0
11	40	26	60	30.33	10	5	0
12	46	28	54	30.39	10	1	0
13	54	42	68	30.11	10	4	0
14	44	26	55	30.37	10	8	0
15	43	22	49	30.35	10	4	0
16	57	48	68	29.95	10	7	0
17	47	32	59	30.08	10	10	0
18	29	8	38	30.68	10	7	0
19	35	11	43	30.52	10	5	0
20	47	45	75	30.2	2	1	0.16
21	62	55	80	30.11	4	3	0
22	65	61	81	29.87	8	6	0.1
23	62	37	53	30.06	9	3	0
24	57	47	68	30.01	10	4	0.01

Figure 5.18: Dataset Used

5.6.3 ML Algorithm

The Machine learning model for predicting rain at a particular time is going to be done by the linear regression model. Linear regression is the method of plotting data points onto a graph. Linear regression can be diverse which has multiple independent variables used as input features and simple linear regression which has only one independent or input feature. Both linear regressions have one dependent variable which can be forecasted or predicted based on the input features. The multivariate linear regression was employed in this study to predict the dependent variable, daily rainfall amount, which was dependent on a number of environmental variables or features.

Using the known environmental factors as input, the supervised machine learning technique of linear regression is utilised to forecast the unknown daily rainfall amount. Multiple explanatory or independent variables (X) and a single dependent or output variable, indicated by Y, were used in the multivariate linear regression. Hence, the general equation of the multiple linear regression is given as:

$$Y_i = \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \ldots + \beta_p x_{ip} + \varepsilon_i = x_i^T \beta + \varepsilon_i \quad \mathrm{i} = 1, 2, 3 \ldots \mathrm{n}$$

where x_i^T is transpose of x_i the input or independent variable, β is regression coefficient, ε_i is error term or noise, Y_i is a dependent variable.

Figure 5.19: Machine Learning Algorithm

Where x_i^T is transpose of x_i the input or independent variable, β is regression coefficient, ε_i is error term or noise, Y_i is a dependent variable.

5.6.4 Source Code for ML rain prediction

```
# Cleaning the data &import the libraries

import pandas as pd

import numpy as np

# read data in pandas dataframe

data = pd.read_csv("bangalore_weather.csv")

# drop (delete) the unnecessary columns in the data

data = data.drop(
```

```
    ['Events', 'Date', 'SeaLevelPressureHighInches', 'SeaLevelPressureLowInches'], axis=1)
 data = data.replace('T', 0.0)
 data = data.replace('-', 0.0)
 # Save the data in a csv file
 data.to_csv('bangalore_final.csv')
# import the libraries
import pandas as pd
import numpy as np
import sklearn as sk
from sklearn.linear_model import LinearRegression
import matplotlib.pyplot as plt
# read the cleaned data
data = pd.read_csv("bangalore_final.csv")
X = data.drop(['PrecipitationSumInches'], axis=1)
Y = data['PrecipitationSumInches']
Y = Y.values.reshape(-1, 1)
day_index = 798
days = [i for i in range(Y.size)]
clf = LinearRegression()
clf.fit(X, Y)
inp = np.array([[74], [60], [45], [67], [49], [43], [33], [45],[57], [29.68], [10], [7], [2], [0],
[20], [4], [31]])
inp = inp.reshape(1, -1)
# Print output
print('The precipitation in inches for the input is:', clf.predict(inp))
print('The precipitation trend graph: ')
plt.scatter(days, Y, color='b')
plt.scatter(days[day_index], Y[day_index], color='r')
```

```
plt.title('Precipitation level')

plt.xlabel('Days')

plt.ylabel('Precipitation in inches')

# Plot a graph of precipitation levels vs no of days

plt.show()

x_f = X.filter(['TempAvgF', 'S0ilMoisture', 'HumidityAvgPercent',
'SeaLevelPressureAvgInches', 'VisibilityAvgMiles', 'WindAvgMPH'], axis=1)

print('Preciptiation Vs Selected Attributes Graph: ')

for i in range(x_f.columns.size):

    plt.subplot(3, 2, i+1)

    plt.scatter(days, x_f[x_f.columns.values[i][:100]], color='b')

    plt.scatter(days[day_index], x_f[x_f.columns.values[i]][day_index], color='r')

    plt.title(x_f.columns.values[i])

# plot a graph with a few features vs precipitation to observe the trends

plt.show()
```

5.6.5 Source Code of Sensor Node

Sensor reading

```
float getTemperature()

{return dht.readTemperature();}

float getHumidity()

{return dht.readHumidity();}

int getMoisture()

{float moisture_percentage;

 moisture_percentage = int( 100.00 - ( (analogRead(sensor_pin)/1023.00) * 100.00 ) );

 return moisture_percentage;}

int getRainData()
```

```
{return digitalRead(rain_dpin);}


Sensor sender code

#include <ESP8266WiFi.h>

#include <espnow.h>

#include "DHT.h"

#define DHTTYPE DHT11

#define BOARD_ID 1

#define dht_dpin 13

#define rain_dpin 12

const int sensor_pin = A0;  /* Connect Soil moisture analog sensor pin to A0 of
NodeMCU */

DHT dht(dht_dpin, DHTTYPE);

// REPLACE WITH RECEIVER MAC Address //Master MAC address
DC:4F:22:77:86:0D

uint8_t broadcastAddress[] = {0xDC, 0x4F, 0x22, 0x77, 0x86, 0x0D};

// Must match the receiver structure

typedef struct struct_message {

   int id;

   float temp;

   float hum;

   int moisture;

   int rain;

} struct_message;

//Create a struct_message called myData

struct_message myData;

unsigned long previousMillis = 0;   // Stores last time temperature was published

const long interval = 300000;       // Interval at which to publish sensor readings
```

```
// Callback when data is sent
void OnDataSent(uint8_t *mac_addr, uint8_t sendStatus) {
  Serial.print("Last Packet Send Status: ");
  if (sendStatus == 0){Serial.println("Delivery success");}
  else{Serial.println("Delivery fail");}
}
void setup() {
  // Init Serial Monitor
  Serial.begin(115200);
  dht.begin();
  pinMode(rain_dpin,INPUT);
  // Set device as a Wi-Fi Station
   WiFi.disconnect();
   WiFi.mode(WIFI_STA);
  // Init ESP-NOW
  if (esp_now_init() != 0) {
    Serial.println("Error initializing ESP-NOW");
    return;}
  // Once ESPNow is successfully Init, we will register for Send CB to
  // get the status of Trasnmitted packet
  esp_now_set_self_role(ESP_NOW_ROLE_CONTROLLER);
  esp_now_register_send_cb(OnDataSent);
  // Register peer
  esp_now_add_peer(broadcastAddress, ESP_NOW_ROLE_SLAVE,1, NULL, 0);
  Serial.println(esp_now_get_peer_channel(broadcastAddress));
  delay(500);}
void loop() {
```

```
  unsigned long currentMillis = millis();
  if (currentMillis - previousMillis >= interval | previousMillis == 0) {
    // Save the last time a new reading was published
    previousMillis = currentMillis;
    //Set values to send
    myData.id = BOARD_ID;
    myData.temp = getTemperature();
    myData.hum = getHumidity();
    myData.moisture = getMoisture() ;
    myData.rain = getRainData();
    if (isnan(myData.temp) || isnan(myData.hum) || isnan(myData.moisture)) {
    previousMillis = 0;
    delay(1000);
    return;}
    //Send message via ESP-NOW
    esp_now_send(broadcastAddress, (uint8_t *) &myData, sizeof(myData));}
}
```

5.6.6 Source Code of Gateway program (Sink Node)

```
#include <espnow.h>
#include <ESP8266WiFi.h>
#include <ArduinoJson.h>
typedef struct struct_message {
  int id;
  float temp;
  float hum;
  int moisture;
```

```
  unsigned int readingId;

} struct_message;

struct_message incomingReadings;

void OnDataRecv(uint8_t * mac_addr, uint8_t *incomingData, uint8_t len) {

  String transferData;

  // Copies the sender mac address to a string

  memcpy(&incomingReadings, incomingData, sizeof(incomingReadings));

  transferData =
"$"+String(incomingReadings.id)+"+"+String(incomingReadings.temp)+"#"+String(inco
mingReadings.hum)+"^"+String(incomingReadings.moisture);

  Serial.println(transferData);}

void setup() {

  Serial.begin(115200);

  // Set the device as a Station and Soft Access Point simultaneously

  WiFi.disconnect(true);

  WiFi.mode(WIFI_STA);

  // Set device as a Wi-Fi Station

  if (esp_now_init() != 0) {

    Serial.println("Error initializing ESP-NOW");

    return;}

  // Once ESPNow is successfully Init, we will register for recv CB to

 esp_now_register_recv_cb(OnDataRecv);}

void loop() {yield();}
```

5.6.7 Source Code of Cloud (Master Node)

```
#include <FirebaseESP32.h>

#include <WiFi.h>

#include <addons/TokenHelper.h>
```

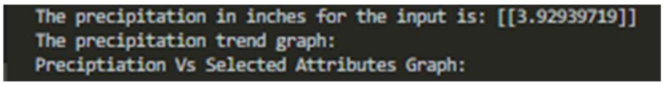
```
#include <addons/RTDBHelper.h>
#define API_KEY "AIzaSyBHEsh7J3sI_iSgRa45ThQIU3aELGDi8ZA"
#define DATABASE_URL "https://wsn-based-data-logger-default-rtdb.firebaseio.com"
#define USER_EMAIL "lavanya4520@gmail.com"
#define USER_PASSWORD "WSNDataLogger@123"
FirebaseAuth auth;
FirebaseConfig config;
// Replace with your network credentials
const char* ssid = "INTERNET";//REPLACE_WITH_YOUR_SSID
const char* password = "ZXCV@098";//REPLACE_WITH_YOUR_PASSWORD
FirebaseData firebaseData;
unsigned long currentRecord = 0;
String Datapath = "";
bool startup = true;
void sendData(String id,float temp,float hum,int moisture,int rain)
{
  FirebaseJson json;
  json.add("temperature",temp);
  json.add("humidity",hum);
  json.add("moisture",moisture);
  json.add("rain",rain);
  currentRecord = getCounter(id);
  if(startup)
  {Datapath = "Day-"+String(currentRecord/24);startup = false;}
  if(currentRecord == -1)
  {currentRecord = 0;setCounter(id);}
  unsigned long perDay = currentRecord%24;
```

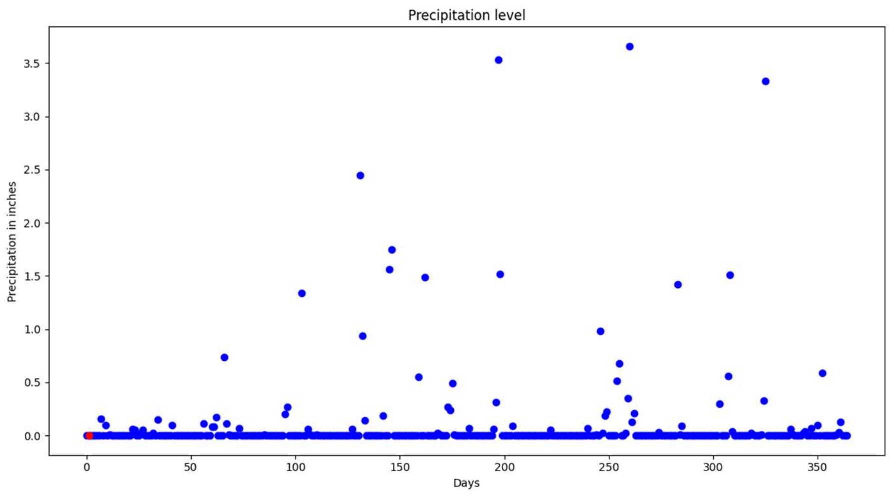
```
  if(perDay == 0)
  {Datapath = "Day-"+String(currentRecord/24);}
  String pathForSave = "lavanyaProject/Node-"+id+"/"+Datapath+"/"+String(perDay);
  sendFirebaseJson(&json,pathForSave);
  currentRecord++;
  setCounter(id);
}
void setup() {
  Serial.begin(115200);
  // Set the device as a Station and Soft Access Point simultaneously
  WiFi.disconnect(true);
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {delay(1000);Serial.print(".");}
  /* Assign the api key (required) */
  config.api_key = API_KEY;
  /* Assign the user sign in credentials */
  auth.user.email = USER_EMAIL;
  auth.user.password = USER_PASSWORD;
  /* Assign the RTDB URL (required) */
  config.database_url = DATABASE_URL;
  /* Assign the callback function for the long running token generation task */
  config.token_status_callback = tokenStatusCallback; // see addons/TokenHelper.h
  Firebase.begin(&config, &auth);
  // Comment or pass false value when WiFi reconnection will control by your code or
third party library
  Firebase.reconnectWiFi(true);
  Firebase.setDoubleDigits(5);
```

```
}
void loop() {
 if(Serial.available())
 {String data = Serial.readString();
   if(data.charAt(0) != '$';return;
   int tMarker = data.indexOf('+');
   int hMarker = data.indexOf('#');
   int mMarker = data.indexOf('^');
   String id = data.substring(1,tMarker);
   String temp = data.substring(tMarker+1,hMarker);
   String hum = data.substring(hMarker+1,mMarker);
   String mos = data.substring(mMarker+1);
   sendData(id,temp.toFloat(),hum.toFloat(),mos.toInt(),0);}
}
```

5.6.8 Test Results

Case 1:





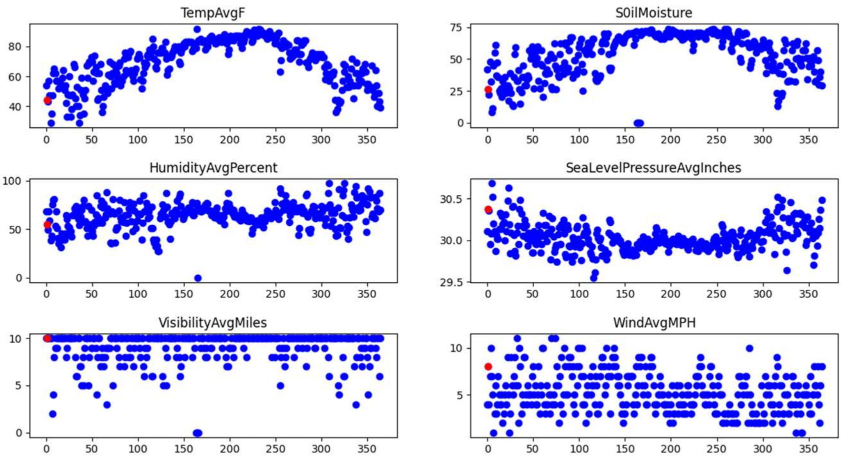


Figure 5.20: Test Cases 1 Result

Case 2:

```
The precipitation in inches for the input is: [[1.98057845]]
The precipitation trend graph:
Precipitation Vs Selected Attributes Graph:
```

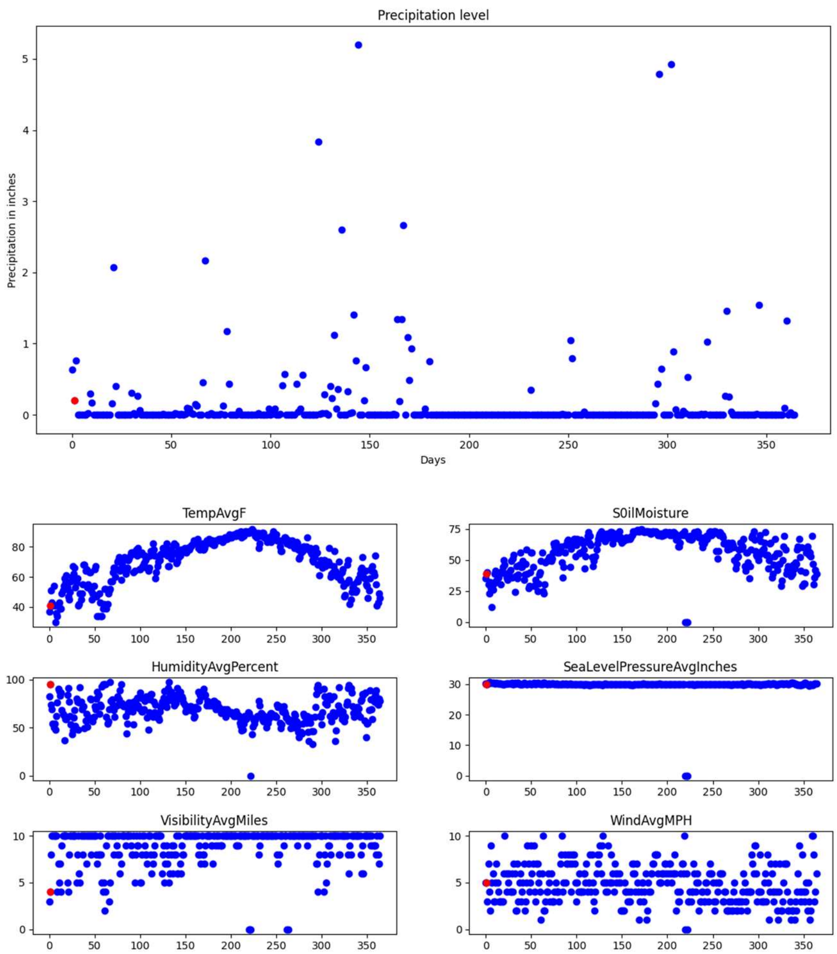


Figure 5.21: Test Cases 2 Result

5.6.9 Flowchart

The complete flow of process of the proposed methodology is shown in below figure. Firstly, an accurate dataset is being collected. There are various websites where users upload datasets which can be used by other users for the sake of analysis. Our dataset is collected from Kaggle. Data is then cleaned to obtain the necessary data for the Machine Learning. Then a specific Machine Learning Algorithm is applied onto the cleaned dataset to produce required information from it. Here, linear regression is used in order to predict the future attack with respect to the data units and their encryption level.

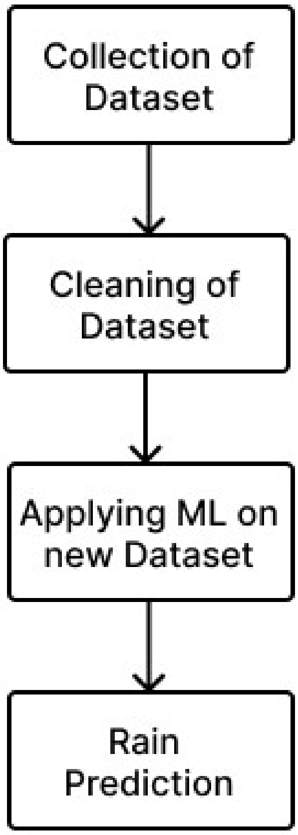


Figure 5.22 Flow Chart of Proposed Methodology

Chapter-6

Experimental Results and Discussion

6.1 Results

The result of the experiment performed showed good potential to be adapted in real world. The data obtained after performing the experiment is as tabulated below.

TABLE V: TABULATION OF COLLECTED DATA ON TESTING

Display of collected data	Node - 1			
	Day - 0			
	At 4:00pm	At 5:00pm	At 6:00pm	At 7:00pm
Temperature (in ^{0}C)	25.3	24.0	23.7	22.4
Humidity (in %)	43	45	56	67
Moisture (in %)	87	84	81	79
Rain (0 or 1)	1	0	0	0

In "Table V," the ambient temperature, humidity, soil moisture content and rain fall are all tabulated. On the first day, the information was gathered from sensor node 1 (day 0). To note the time at which this data was obtained, the sensor inserts a timestamp. Data can be received from the other nodes and forwarded to the master node in a manner similar to how the data from the first node is tabulated.

The designed firmware is extremely dynamic and can adapt to numerous nodes. The master node can manage an increase in the number of hardware nodes or the addition of new sensors to an existing sensor node with little to no modifications to the firmware. Due to the usage of Firebase Hosting, which is accessible from anywhere in the globe, the user has a lot of flexibility when accessing the data.

```
The precipitation in inches for the input is: [[3.92939719]]
The precipitation trend graph:
Preciptiation Vs Selected Attributes Graph:
```

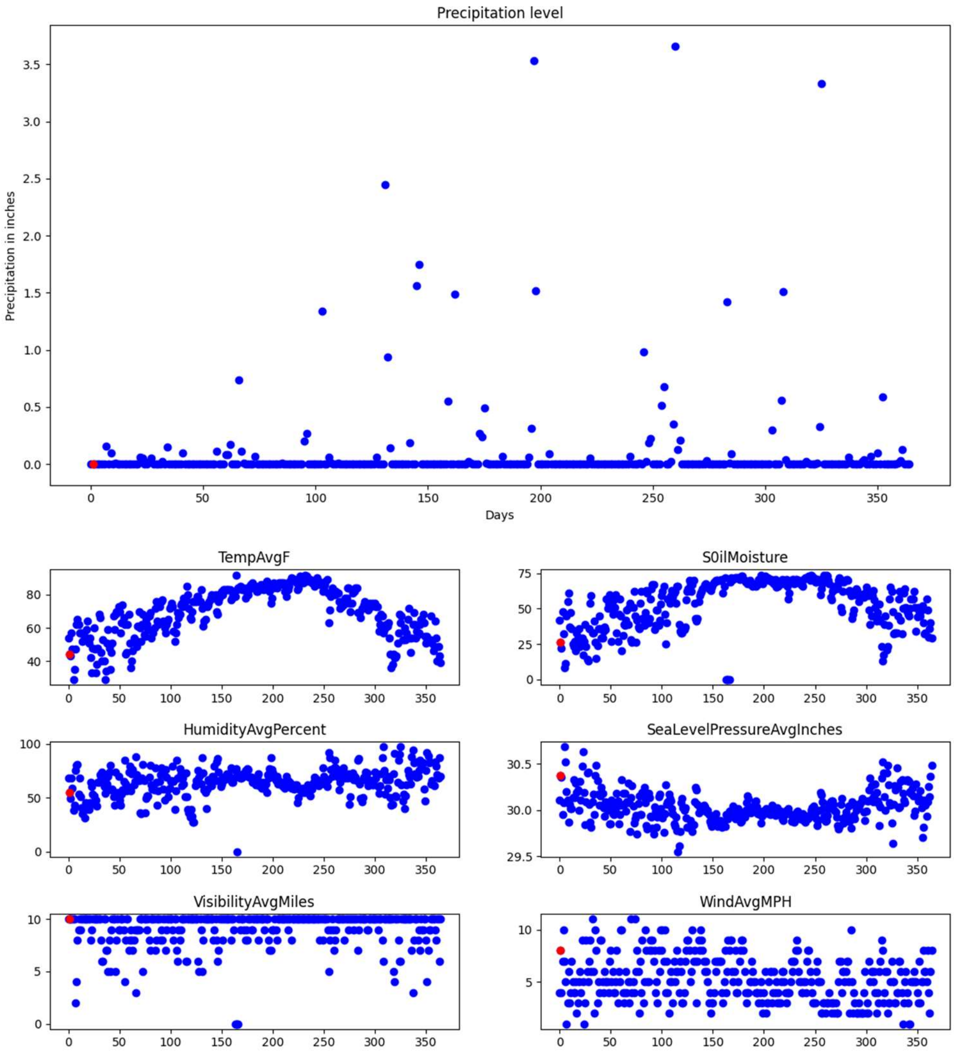


Figure 6.1: Machine Learning Algorithm Implemented

The following figure shows precipitation level which tells us about the rainfall with the help of other paraments. The size of the data set collected from the dataset for this paper was appropriate to use the machine learning algorithms called multivariate linear regression that can estimate the daily amount of rainfall in the region. This technique can demonstrate the degree to which each environmental factor affects the daily rainfall intensity.

6.1.1 Quality Metrics

The important parameter in implementing such systems practically would be battery life management. The battery needs to be charged and recharged every now and then to maintain the sensor nodes. Few experiments were performed to measure the current consumption of sensor nodes while being used and while in idle state. While performing the experiment, the data was transmitted once per hour from the sensor node to the master node. The device's current consumption was measured to be 170mA for 40ms, during data transmission and 80mA while it was idle. The battery can theoretically power the sensor node for 435.356 hours, or around 18 days and 3 hours, if we can include a light sleep mode into the NodeMCU that shuts off the Wi-Fi. Here, the current consumption drops to 10mA. The circuit can manage to do better with a little bit more optimization, and by adding a deep sleep mode to NodeMCU, the battery life can be increased even further.

TABLE VI: TABULATION OF CURRENT CONSUMPTION IN VARIOUS STATES OF SENSOR NODE

State of the Sensor Node	**Current Consumed**
While transmitting the data	170mA
In idle state	80mA
When in Sleep Mode (No Wi-Fi connectivity)	10mA

The battery can be prolonged by other methods like selecting a battery with higher wattage or by keeping lesser number of sensors, etc.

6.2 Applications

- Agriculture is the backbone of India. One of the fundamental aspects that we can improve in agricultural field is by getting more data from soil, atmosphere, plants, etc accurately.
- By collecting more data, we can apply machine learning and prediction algorithms to figure out the amount of fertilizer, water and other manures required for crops to get better yield.

6.3 Advantages and Disadvantages

6.3.1 Advantages

- Wireless Sensor Network is reliable and fast.
- When offline, data is stored and uploaded when Wi-Fi connection is established.
- Data packets are not lost.

- All the nodes are battery operated, hence portable.
- Sensor nodes are customizable.
- Wireless Sensor Network (WSN) based data logger system for collecting data accurately from agricultural field.

6.3.2 Disadvantages

- Battery has to be monitored and recharged.
- To increase area coverage, more hardware is required.

Chapter-7

Conclusion and Future Scope

7.1 Conclusion

Agriculture plays an important role in every human's life. It is one of those fields which require dire need of technology especially when India's population is growing. Hence, our project aims to collect, monitor and store data accurately. It is further subjected to ML to predict rain to demonstrate how collected data can be used further. The project also aimed in being flexible to be able to adapt in real life agricultural field.

To increase the yield of agricultural corps, implement smart farming, collect data from the agricultural land efficiently, store and process, various research papers were referred. This paper presents the literature review of various methods and technologies that can be used to implement a system which achieves this goal.

Various methods for data logging, effective usage of hardware along with aiming cost effective methods were found out. Steps to be taken for collection of data with minimum hardware should be achieved. Data transmission is also one of the interested fields; where the collected data is sent to cloud. Formation of Wireless Sensor Network was studied in many papers. Different approach of implementing and practical problems that could be faced was presented in the paper. Research conducted to overcome these problems is also discussed in the paper. Domination of WSN as a practical, implementable and cost-effective method over other data collection methods was discussed.

Transmission and storage of data were also discussed as a part of the problem. In this area, after the reception of data, effective system has to be implemented to store it. If not, the data would be of no use. This system had to be discussed because the farming area might pose unforeseen problems because of network issue. To overcome these issues, referring few research papers has been vital.

As the final stage, the collected data has to be used in effective ways. In this stage, the system becomes very flexible according to the needs of the user. This system is then used to predict rain or other agricultural variables to help achieve the goal of smart farming and data driven agriculture. Few research papers are discussed here in this field as well.

7.2 Future Scope

Data Collection is aimed to be optimized in this project. This can be taken forward as demonstrated before; the collected data can be subjected to further AI/ML algorithms to implement useful strategies in agricultural field. Or it can also be used to predict rain, storm, and etc. events.

The project can also be developed further and additional physical layers can be added to shield the modules like sensor node and master node from environmental harshness. This also becomes necessary as the modules will be subjected to harsh environment for long duration of time. By protecting the modules from environmental changes, the life of modules can be increased along with their durability and effective performance.

The design of the system can also be optimised in many ways. For example, in increasing the distance coverage, instead of ESP-NOW protocol, LoRa modules and communication can be used as it gives up to three miles (five kilometres) in urban areas, and up to 10 miles (15 kilometres) or more in rural areas (line of sight).

Other improvement as a future scope would be to include an actuator which controls the watering pump according to ML rain prediction. This would make the system completely automatic, reducing the work of the farmer while taking care of the crops.

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Annexure-I: National Conference Paper

IOT AND WIRELESS SENSOR NETWORK (WSN) BASED DATA LOGGER SYSTEM WITH RAIN PREDICTION USING ML

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Abstract – This paper brings out how agriculture has been the back bone of India as it is the case with many countries. But the use of modern technology for this sector's development has been slow. To increase the availability of technology for the improvement of crop yield should be kept in mind and worked on. For ages the traditional method of farming has been the practice in India.

Here, farmers have very little knowledge on rain prediction or on the change of soil fertility and other important aspects of farming. Because of this, the current trend of increase in demand for food and agricultural yield is hard to be satisfied. Hence proper research is done on various technology that can be implemented in the field of agriculture which will aim at smart farming, sending the data to cloud using IoT and Firebase, using ML algorithms to predict rain or other desired features so we can manage with limited resources and get improved crop yield while managing the limitations.

Keywords – *Wireless Sensor Network, Linear Regression, Naïve Bayes Algorithm, Smart farming, Rain prediction.*

I. INTRODUCTION

Agriculture has not changed much since the beginning of farming. With advancements in technology, we have come to such an era that we can improvise the methods and the way the farming has been done. Advancement in technology in every field has been on an increasing level from the past few decades. It is done in a few important sectors; which will help us with the issue of comprehending and predicting these climate occurrences that is caused by changes in global temperatures, natural disasters in the last three years, rising sea levels and shrinking polar region. Prediction is crucial, and they can be run and simulated as computer models to forecast climatic variables such as temperature, precipitation, and rainfall.

Using this for rain prediction in the area which has to be cultivated is a huge improvement in this field. Another technology called Wireless Sensor Network (WSN) can be used to collect the data from agricultural field in an efficient, cost-effective way. Implementing this will enable us to collect data from sensor nodes and transmit the same using the master node. Once this technology is deployed, we can send the data to cloud using Firebase and apply ML algorithms on it. This enables us to predict the feature we require based on the data collected. Hence, the data can not only be collected with minimal corruption, but it can also be logged and used to take decisions in such a way that it improves the quality of farming, increases the yield along with saving water as much as possible. Such a method is an efficient method for the current trend of increasing population and demand with limited resources which are being depleted. This data driven farming should help us achieve our goal.

II. OUTLINE OF THE PROJECT

Our proposal relies on the idea of a wireless sensor network (WSN), in which a sensor node gathers information from several sensors such as humidity, temperature, and soil moisture content.A sink node, also known as a base station or master node, gathers data from several similar sensor nodes and delivers it to a cloud database where it may be analyzed and displayed to make predictions or automate and manage real-time machinery.

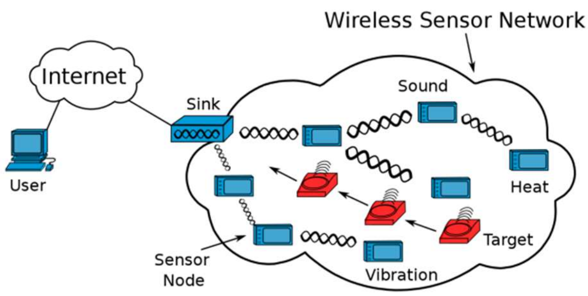

Fig.1: Overview of Wireless Sensor Network (WSN)

The operation of a wireless sensor network (WSN) is depicted in the previous figure ("Fig. 1"). To interact with users through the internet, a sensor node made up of several sensors is linked to a sink node.Our technology has the advantage that the sink node is not reliant on the quantity of sensor nodes, making it simple to expand the kind or number of sensors without altering the sink node. For the communication portion, there is a proprietary protocol called ESP-NOW [2] that is based on IEEE 802.11 vendor-specific action frames. The sensor node may become inactive once the data has been transferred from it. The data transfer operation will repeat once the user-specified time interval has passed. With this protocol, the sensor node uses just 170mA while transmitting data and 80mA when it is idle.

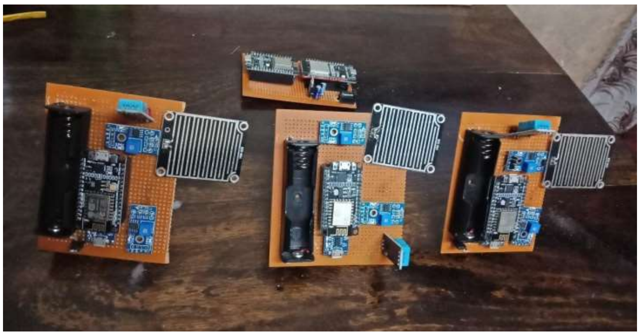

Fig 2: IoT based Agriculture system(overview)

The image of our functioning prototype of a WSN-based data logger, which comprises of sensor nodes and sink nodes, is displayed in "Fig. 2."

The sink node is made up of a master receiver (NodeMCU), which collects data from sensor nodes and transmits it via UART to an ESP8266-01 Wi-Fi module, which then sends the data to the internet. Having these two distinct systems has the benefit of keeping the system very modular. The master receiver may still receive data from the sensor node without any change if this WSN-based data logger has to be put in a remote location without access to the internet. We may send the information to a local server or Raspberry Pi, which can do the necessary calculation on-site and display the real-time data to the user over a local network or a physical dashboard.

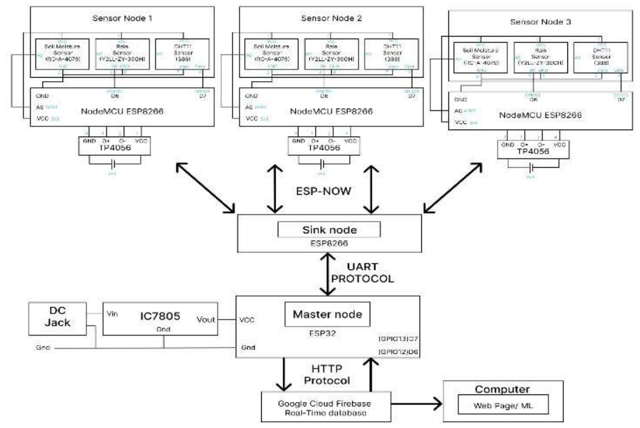

Fig 3: WSN based data logger system (circuit diagram)

As shown in figure 3, the overview of the circuit diagram of WSN based data logger system. Our sensor nodes consist of three sensors and a microcontroller. A single battery is used to power the circuit. Although sensor node can contain any sensor the user wishes, we have used DHT11 sensor, rain sensor and resistive moisture sensor**.**

III. HARDWARE IMPLEMENTATION

A. Sensor node

For sensor node, as the name indicates, it contains various sensors that are required to measure various parameters of the agricultural field. As mentioned before, each piece of land is volatile. It is different; hence according to the need of the farmer, they can put the appropriate sensor to collect the parameters that are valuable to them. In our case, we have used DHT11 sensor, rain sensor and resistive moisture sensor. The DHT11 sensor is used to measure temperature and humidity of the environment.

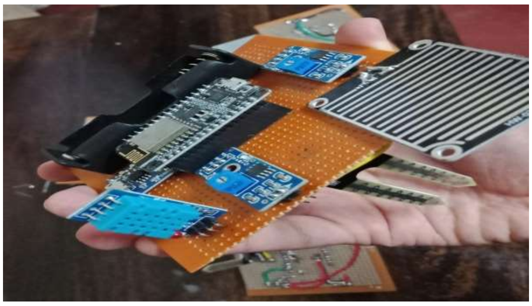

Fig. 4. Sensor Node of the WSN data logger

As shown in Fig. 4, the sensor node contains afore mentioned sensors. The rain sensor measures the rain. Its output is binary that is 0 or 1 where 0 indicates no rain and 1 indicates that there is rainfall. This can be improved as there is a potentiometer provided with the sensor so we can adjust the sensitivity of the rainfall according to our need. The final sensor is the resistive moisture sensor. This sensor measures the soil moisture content. Again, the sensitivity of this can also be adjusted. Along with this, the sensor node contains a single cell rechargeable battery with TP4056 circuit to charge it and NodeMCU.

B. Sink node

The function of sink node is basically to collect the data from all the sensor nodes connected and send it to master node. The sink node is collecting all the data from sensor nodes using ESP-NOW protocol. Because the ESP NOW protocol only functions amongst the family of ESP created by Espressif, NodeMCU is utilised as a microcontroller [3]. The ESP8266-01 is used in conjunction with the microcontroller to transport the acquired data from the microcontroller to the firebase database. Although NodeMCU has integrated Wi-Fi, we still utilise an external Wi-Fi module since we can quickly convert to other communication types [GPS, LORA, ZIGBEE, etc.] because we employed UART connection between the microcontroller and the Wi-Fi module in the event that Wi-Fi communication is not available [4].

C. Master node

The master node contains ESP32 and its function is to collect data from Sink Node using UART protocol and to send the same data to a cloud storage using HTTP protocol. The sink node and the master node are physically connected using the Rx and Tx pins and hence, they are together.

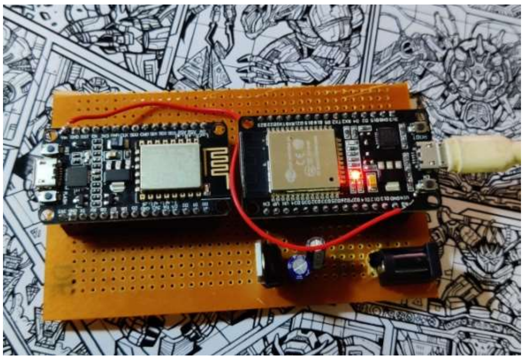

Fig. 5. Sink Node and Master Node

As shown in the figure, the sink node and master node are physically together and their function is to collect data from sensor node and to send it to cloud storage, Firebase from Google. A sensor node may be designed to provide data at any interval, and because the master is always powered, it can receive data from any sensor node at any time.

IV. FIRMWARE IMPLEMENTATION

This prototype's programming was carried out using an Arduino IDE that also has an installed ESP8266 core (the ESP8266 core is described in depth in [3]). Adafruit DHT sensor library for DHT sensor and a straightforward analogue read were used to read the sensor data from the sensor node for the moisture sensor. ESP NOW was used to transport data from the sensor node to the sink node [5].

Both the sensor node and the sink node have a structure (struct) in the code that specifies the precise data types and structure size. Data from the sensor node is transmitted along with this structure, together with the mac address and an ID to identify the sensor node from which the data was received. When the data is received, it is digested into a JSON object by Mobizt [6] before being transferred to Firebase using Firebase-ESP8266. Sink node handles the dynamic nature of adding more nodes since it can distinguish between various nodes, produces a new JSON Object with a distinct node name, and then pushes this data to Firebase.

V. COULD DATABASE FOR DATA STORAGE

The data collected has to be stored to do any further analysis with it. For storage, we have used could storage. This has many advantages like it can be accessible all the time; it can be accessed from anywhere, etc. Firebase, a google cloud data storage provides data storage facilities along with further expansion into running AI/ML algorithms to it. It also provides real time viewing of data collected.

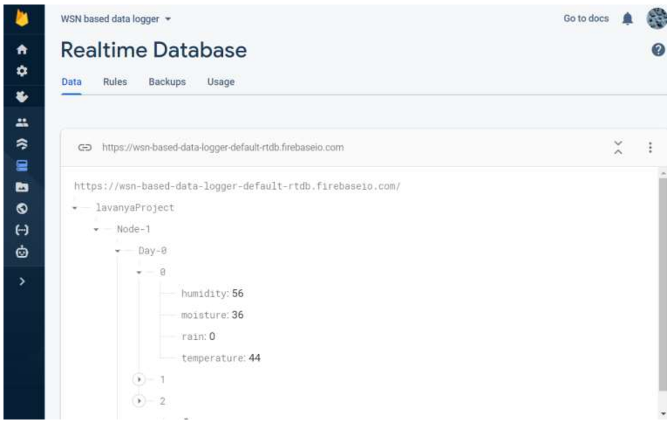

Fig. 6. A snapshot of could storage showing the data in realtime

As shown in the firuge (Fig. 6), the data is collected real time and stored in cloud storage.

This is a service provided by Google to collect, store and monitor data. Google has created a platform called Firebase for building mobile and web applications[7]. Since Firebase makes it simpler to host websites and create mobile applications using an existing database, it was picked.

The user may easily and securely log in using their email to access their statistics thanks to Firebase Authentication. This is also readily expandable to support additional login ways, such as Facebook, phone, or any other.The data stream originating from the sensors is kept in a real-time database. Any change in the data will be immediately displayed on the dashboard because the database is real-time.

VI. ML DEVELOPMENT

The Machine learning model for predicting rain at a particular time is going to be done by the linear regression model. Linear regression is the method of plotting data points onto a graph. Linear regression can be diverse which has multiple independent variables used as input features and simple linear regression which has only one independent or input feature. Both linear regressions have one dependent variable which can be forecasted or predicted based on the input features. The multivariate linear regression was employed in this study to predict the dependent variable, daily rainfall amount, which was dependent on a number of environmental variables or features. Using the known environmental factors as input, the supervised machine learning technique of linear regression is utilised to forecast the unknown daily rainfall amount. Multiple explanatory or independent variables (X) and a single dependent or output variable, indicated by Y, were used in the multivariate linear regression. Hence, the general equation of the multiple linear regression is given as:

$$Y_i = \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \ldots + \beta_p x_{ip} + \varepsilon_i = x_i^T \beta + \varepsilon_i \quad \mathrm{i} = 1, 2, 3 \ldots \mathrm{n}$$

Fig 7: Linear Regression equation

where x_i^T is transpose of x_i the input or independent variable, β is regression coefficient, εi is error term or noise, Y_i is a dependent variable.

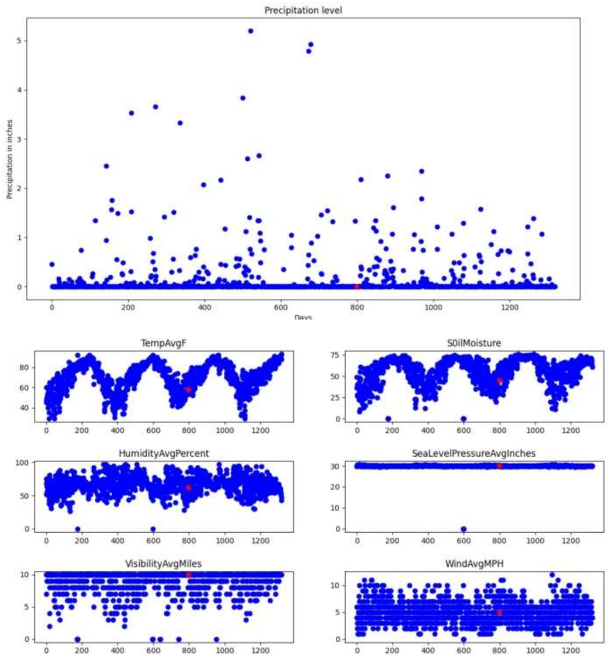

Fig 8: Rain prediction using ML

The size of the data set collected from the dataset for this paper was appropriate to use the machine learning algorithms called multivariate linear regression that can estimate the daily amount of rainfall in the region. This technique can demonstrate the degree to which each environmental factor affects the daily rainfall intensity.

VII. RESULT

The result of the experiment performed showed good potential to be adapted in real world. The data obtained after performing the experiment is as tabulated below.

TABLE I. TABULATION OF COLLECTED DATA ON TESTING

Display of collected data	Node - 1			
	Day - 0			
	At 4:00pm	At 5:00pm	At 6:00pm	At 7:00pm
Temperature (in ^{0}C)	25.3	24.0	23.7	22.4
Humidity (in %)	43	45	56	67
Moisture (in %)	87	84	81	79
Rain (0 or 1)	1	0	0	0

In "Table I," the ambient temperature, humidity, soil moisture content and rain fall are all tabulated. On the first day, the information was gathered from sensor node 1 (day 0). To note the time at which this data was obtained, the sensor inserts a timestamp. Data can be received from the other nodes and forwarded to the master node in a manner similar to how the data from the first node is tabulated.

The designed firmware is extremely dynamic and can adapt to numerous nodes. The master node can manage an increase in the number of hardware nodes or the addition of new sensors to an existing sensor node with little to no modifications to the firmware. Due to the usage of Firebase Hosting, which is accessible from anywhere in the globe, the user has a lot of flexibility when accessing the data.

VIII. CONCLUSION

Agriculture plays an important role in every human's life. It is one of those fields which require dire need of technology especially when India's population is growing. Hence, our project aims to collect, monitor and store data accurately. It is further subjected to ML to predict rain to demonstrate how collected data can be used further. The project also aimed in being flexible to be able to adapt in real life agricultural field.

IX. FUTURE SCOPE

As demonstrated before, the collected data can be subjected to further AI/ML algorithms to implement useful strategies in agricultural field. Or it can also be used to predict rain, storm, etc. events. The project can also be developed further and additional physical layers can be added to shield the modules like sensor node and master node from environmental harshness.

ACKNOWLEDGMENT

We would like to thank our guide Mr. Ramakrishna S for guiding our project. We would also like to thank our families and friends for their support and encouragement.

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Annexure-II: Plagiarism Report

Plagiarism Checker X Originality Report

Plagiarism Quantity: 12% Duplicate

Date	Wednesday, July 20, 2022
Words	1144 Plagiarized Words / Total 9544 Words
Sources	More than 138 Sources Identified.
Remarks	Low Plagiarism Detected - Your Document needs Optional Improvement.

Chapter-1 Introduction 1.1 Background India is set to be the most populated country within the first quarter of this century. With the huge populous comes the problem of feeding it. Agriculture is a vital part of India's economy and its backbone. Research and surveys have shown that as much as 18% of India's Gross Domestic Production is accounted by agriculture [1]. Indian agriculture provides employment to around half the country's workforce accounting for almost around 600 million people. The task of feeding the entire country and also exporting food to other countries is a tough one. This is made even riskier taking into account the lack of predictability when it comes to weather patterns due to climate change. The advancement in technology has helped many fields in the real world making the lives of entrepreneurs, workers and customers easy alike [2].

Yet the implementation of the technological marvels in the field of agriculture has been rather slow especially in India. Wireless Sensor Network (WSN) based data logger system for collecting data accurately from agricultural field. One of the fundamental aspects that we can improve in agricultural field is by getting more data from soil, atmosphere, plants, etc accurately. By collecting more data, we can apply machine learning and prediction algorithms to figure out the amount of fertilizer, water and other manures required for crops to get better yield. But in developing countries like India, cost of the technology is quite not affordable for implementing in large scale. Hence an effective and low-cost real-time monitoring system is needed, to monitor and collect data accurately [1].

Networks of specialized, geographically scattered wireless sensors that track and record environmental physical conditions and transmit the gathered information to a central point are known as wireless sensor networks. Environmental factors like temperature, sound, pollution levels, humidity, and wind can all be measured by WSNs. Our project relies on the idea of a wireless sensor network (WSN), in which a sensor node gathers information from several sensors such as humidity, temperature, and soil moisture content. The main activities involved are data collection, processing, and variable rate of application of inputs. We can reduce a lot of manual work in the field of agriculture using automation [3].

The major problem faced in many agricultural areas is that lack of mechanization in agricultural activities. In India, agricultural work is done by hand using traditional equipment like a sickle and a plough. Our Smart Farming System automates agricultural tasks while reducing manual labor. Because to the use of synthetic fertilizers and pesticides, the groundwater is contaminated. In smart farming, organic fertilisers like compost, animal dung, and green manure are used in their place to improve the soil's structure. 1.2 Smart Irrigation and Farming We started to explore the recent trends in perpetration of ICT in smart husbandry ways. In the meantime, we did a brief erudite check on the published workshop of prestigious scholars in this field.

A new approach for Digital Agriculture was proposed describing connections between Precision Agriculture, Digital Earth, Information Agriculture, Virtual husbandry, and Digital Agriculture. The demand to put forward the conception of Digital Agriculture was bandied. Detector data collection and irrigation control was put forward on vegetable crop using smartphone and wireless detector networks for smart husbandry. The

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environmental data can be collected and the irrigation system can be controlled using smartphone. A unique smart husbandry system grounded on pall computing was suggested for the early identification of tomato borer insects. Exercising IOT and pall computing, this issue is resolved. For multifunctional vehicle route control and data collection grounded on Zig- Beemulti-hop mesh network, real- time monitoring of GPS-shadowing was recommendec.

It condenses the section on path planning for a multipurpose vehicle. The vehicle shadowing system communicates with one another using the ZigBee wireless network and the global positioning system(GPS). A case study pressing the operation of a variety of environmental detectors and beast monitoring systems on an experimental smart ranch as part of the Web of effects for husbandry has been proposed. A system that specifies the alert was tested in a husbandry area and the results were analyzed. The linked cell was used which allows longer- term analysis and data participating to a larger scale. From the below erudite check, we've set up a new approach using a smart seeing system that keeps track of the external environmental factors and does communication with the smart irrigator system to perform necessary tasks that are needed for husbandry.

In this system, we've furnished a resolution for the problems faced by the growers. The main problems faced by them are electricity deficit, homemade labor work, lack of robotization, knowledge deficiency about husbandry, and not knowing about the acceptable operation of macro mineral contents (N, P, and K). Our system does the job of seeing and also habituates to the surroundings. Fresh- water failure is one of the biggest problems faced by numerous nations in the world and the problem is getting adverse with time due to increase in population and hamstrung operation of fresh water.

Grounded on a United Nations report, the world population (around7.6 billion presently) is anticipated to increase to8.6 billion by 2030,9.8 billion by 2050 and11.2 billion by 2100 with roughly adding 83 million people monthly. Agriculture sector attract a large quantum of water in irrigation practices [6]. In India, a water stressed nation, around 80 of brackish coffers are used in husbandry sector. The traditional irrigation ways don't use water optimally, which raises a need for perfection husbandry with smart irrigation. In recent history, the penetration of Information and Communication Technologies (ICT) has bettered significantly in pastoral areas.

1.3

Machine Learning Integration Internet of effects (IoT) and machine literacy (ML) grounded results have a great eventuality to ameliorate the agrarian geography. The results can be used in colorful confines, e.g., smart irrigation; monitoring and control; agrarian yield and Agri- resource operation; agri- business operation. IoT technology is grounded on connecting operation specific objects (with detectors and/ or selectors) with Internet and intelligently assaying (using ML) the data entered from the objects for making perceptive opinions. The ML is a branch of Artificial Intelligence (AI), which helps machines in taking independent opinions. The smart irrigation ways have gained important attention in recent history.

numerous irrigation systems are proposed grounded on wireless detectors networks (WSN), IoT and Artificial Intelligence (AI)/ ML. A smart collection of detector system for scheduling irrigation. In this system, a detector circuit board is equipped with detectors for soil humidity, thermocouples and active RFID (Radio frequency Identification) transmitter. Gutierrez proposed automated smart irrigation system. This system uses a Smartphone irrigation detector which comprises of bedded camera, photovoltaic panel, Smartphone holder, illumination pole and anti-reflective glass. Joaquin developed an automated system for irrigation using Wireless Sensor Network and mobile data (GPRS) communication Module.

Colorful machine literacy (ML) ways to develop smart model that were having capability to prognosticate daily irrigation plan by the help of agriculturist's knowledge [3]. Real time automated smart irrigation system using pall of effects and Thermal Imaging. Thermal imaging fashion is grounded on the analysis of heat hand images (infrared imaging) of the objects. The thermal imaging ways can be used in measuring colorful parameter like water stress position, irrigation distribution, factory temperature and cover temperature for agrarian/ irrigation affiliated operations. An irrigation system grounded on the threshold value of cover temperature for cotton crop was proposed and its results shown a better growth over the traditional styles.

It was proposed IoT grounded smart irrigation operation system grounded on Machine literacy (ML) ways. It's

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an automated irrigation operation system to prognosticate unborn soil humidity of forthcoming days [7]. The system uses the field data collected via detectors placed in a field and the rainfall data from rainfall soothsaying spots. The vaticination of unborn soil humidity could be veritably helpful in effective provisioning and operation of water in irrigation. An effective perpetration of machine literacy ways for soil humidity vaticination is a grueling and open exploration direction. This paper considers ML grounded ways for vaticination of soil humidity of forthcoming days grounded on the detectors data entered from the field and the rainfall cast information.

The detectors knot stationed in the field collects data for current soil humidity, soil temperature, environmental temperature and moisture, which is used for unborn soil humidity vaticination. Chapter-2 Literature Survey 2.1 Design and Development of Wireless Sensor Network based data logger with ESP-NOW protocol The paper describes the agriculture is one of the most important sectors of the Indian economy, accounting for 18% of the country's Gross Domestic Product (GDP) and employing 50% of the country's workforce. The demand for food in India is rising in tandem with the country's growing population. Though AI and ML have advanced weather prediction, deploying technology for agriculture on a broader scale is extremely tough.

This is primarily due to the 3C's: The cost of deploying technology, the connectivity of technology, and the complexity of technology are all factors to consider. This is based on the wireless sensor network concept, in which a sensor node collects data from various sensors such as humidity, temperature, and soil moisture content. A sink node (also known as a base station or master node) collects data from a number of similar sensor nodes and delivers it to a cloud database, where it can be displayed and analyzed for prediction or to automate and manage real-time machinery. The benefit of the device is that the sink node is unaffected by the number of sensor nodes, making it very simple to expand the type/number of sensors without modifying the sink node ESP-NOW. The data was collected from sensor node.

The sensor adds timestamp to record the time at which this data was collected. Similarly, data can be received from the rest of the nodes and can be sent to the master node. The firmware developed has very dynamic nature of adjusting to multiple nodes. As the number of nodes in hardware grows or addition of different sensors in the existing sensor node can be handled by the master node with very little or almost no changes to be made in the firmware. Accessing the data by the user is also very flexible as Firebase Hosting is used, which can be accessed all over the world. Conclusion can be drawn that advancement in the field of agriculture is not only vital with India's growing population but is also long overdue.

Hence our system aims at monitoring and collecting data accurately which can be further subjected to any form of AI or ML algorithms to make use of the collected data. By using Wireless Sensor Network (WSN) based data logger system with ESP-NOW protocol our project was able to collect data in a dynamic and flexible way. This project is not only efficient but also quite practical. 2.2 Smart farming system using sensors for agricultural task automation This paper describes an investigation of contemporary trends in the use of ICT in smart farming approaches. It also describes a novel approach including a smart sensing system that monitors external environmental conditions and communicates with a smart irrigation system to accomplish important farming operations.

It provides a solution to the farmers' problems with this approach. Two modules are employed: a smart farm sensing system and a movable smart irrigation system that travels along a mechanical bridge slider. Microcontrollers, sensors, and a GSM module are used in both systems to communicate with each other and with the outside world. The soil Moisture sensor in the smart farm sensing system detects the moisture content. Smart sensing technology produces precise findings, and Smart irrigator system sprays the required nutrients in accordance with the crops' needs. The irrigator system sprinkled an adequate amount of water based on the soil moisture content data. In India 70% of its population earns it livelihood from agriculture. The inordinate majority contributes only 18% of the GDP. The key reason for this deprived performance is lack of agricultural task automation.

Our Smart sensing system provides precise results and the Smart irrigator system manages to spray the necessary nutrients according to the requirements of the crops. Based on the moisture content results of the soil, adequate amount of water was sprinkled by the irrigator system. We are developing a user-friendly smart farming system which will liberate agricultural productive force greatly, change the mode of production, and

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realize a qualitative leap in agricultural activity. 2.3 Machine Learning based soil moisture prediction for Internet of Things based Smart Irrigation System This paper states that the biggest disadvantage is the whole of the agricultural yield depends upon the weather; which is too big a risk to take.

This is can be helped by using smart agricultural system. Smart Irrigation system basically refers to watering the crops in agricultural field based on the data obtained. The traditional method of predicting the amount of water required is discarded here. The data collected speaks for the accurate amount of water required. This is shown to produce increased efficiency. Smart irrigation system becomes necessary as crop yield can be increased and watering the plants plays a major role in it. This can be achieved by the collected data. Soil moisture is predicted in this paper based on the soil moisture content collected. This is done using capacitive soil moisture sensor. To optimize the water usage in irrigation an IoT and ML based approach is presented in this paper.

As the soil moisture plays the critical role in measuring optimum water usage in irrigation, the ML techniques are used for prediction of soil moisture of upcoming days based on the sensors' data collected from the field and the weather forecast information. The results are analysed for multiple ML techniques and the results of GBRT based approach are very encouraging. Such kind of techniques could help in achieving optimum utilization of precious fresh water resources in irrigation, which is a need of the hour in many waters stressed countries like India. 2.4 Improved the efficiency of IoT in agriculture by introduction optimum energy harvesting in WSN This paper describes Internet of Things as the most effective study topic because sensor nodes and smart devices can collect data from many sources and communicate it with a server without the need for human intervention. Wireless sensor networks, in which data is shared and communicated with the use of sensor nodes, are the most essential idea in IoT.

These sensor nodes are dispersed at random over the defined area in order to collect and sense data on various characteristics. We apply the concept of energy harvesting because sensor nodes have limited energy or backup power. These solar-powered sensor nodes will be used to track crop management, water management, pesticide monitoring, and climate change. In this study, an Internet of Things (IoT) based wireless sensor system is developed, which employs the notion of energy harvesting in agriculture to build, monitor, and control the system's growth and productivity. This paper presents the Internet of things-based agriculture system using the concept of the wireless sensor network. With the help of this system crop management, temperature monitoring, humidity controlling, etc.

became more efficient because farmer can schedule all upcoming task and events on the system, if there is any issue like temperature or water, sensors can sense the data immediately and passes this information to the server so that the system can manage scheduled events according to the collected information. One main issue in this system is the limited battery power of sensor nodes so here author use the concept of energy harvesting through solar energy; it is a wide source of energy from the environment. To utilize this energy in smart agriculture with the help of IoT and WSN technologies produce successful results in the field of agriculture. 2.5 Modern Agriculture Using Wireless Sensor Network (WSN) Here, it is explained how the WSN assists the farmer in producing a large quantity of crop while lowering the yield cost.

Climate change, environmental change, and natural disasters all have an impact on agriculture. Soil and water management can be done with WSN. Because wireless sensors are employed, the implementation costs are very inexpensive. Wireless sensor nodes are employed to monitor the crops in this paper. Sensors can be used to detect temperature, humidity, and other types of theft. This aids in increasing agricultural productivity. Agriculture is a vital source of food for all living beings. However, various environmental changes are affecting agriculture crops nowadays. In order to overcome this, WSN plays a vital role in agriculture. WSN is used in agriculture for monitoring, temperature measurement, irrigation system monitoring, water supply monitoring, and so on. WSN assists the farmer in producing a large quantity of crop while lowering the yield cost.

The smart farm helps the farmer to yield high profit by growing the crop without infection and at exact soil moisture content. Due to automatic process, it reduces the human effort and view the growth of crop through smart phone. The wireless communication reduces the cost of implementation. In future this is implemented for large area of land. The internet connectivity is required at all the time to communicate the data to farmer. The predefined prediction of weather condition helps the farmer to cultivate the crop based on weather

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<1% https://www.techopedia.com/definition/97
<1% https://ukdiss.com/examples/rainfall-pre

condition. Agriculture can be done in this modern world using many latest technologies. The farmer can operate mobile phones from anywhere at any time. This application can group many farmers into it and also the specialist. This is more suitable for agriculture dependent countries like India. 2.6

Rainfall Prediction using Multiple Linear Regressions Model The paper describes how Machine learning approaches are thought to be accurate and have been widely employed as a substitute for traditional weather forecast methods. The rate of rainfall is one of the most important aspects of the weather system, since it has a direct impact on the agricultural and biological sectors. The goal of this study is to create a multivariate linear regression model that can predict the rate of precipitation (PRCP), or rainfall rate. In this paper, authors have used multiple linear regression model to predict the rate of precipitation (i.e., rainfall rate) for Khartoum state, based on some weather parameters taken as the independent variables Those weather parameters are the mean temperature, maximum temperature, minimum temperature, Dewpoint, sea level pressure, station pressure, mean visibility and wind speed. It was found that obtained results show that the mean square error between actual and predicted values of the rainfall precipitation rate (PRCP) has been significantly decreased during testing time.

It has been found to be 85% when the amount of test data equals the amount of training data and 59% when more test data is used. Explanation of this reduction needs supplementary research. For example, it may indicate that the model used needs more data in the training phase. 2.7 Prediction of Climate Variable using Multiple Linear Regression This paper describes the issue of comprehending and predicting these climate occurrences could be caused by changes in global temperatures, natural disasters in the last three years, rising sea levels, and shrinking Polar Regions. Prediction is crucial, and they can be run and simulated as computer models to forecast climatic variables such as temperature, precipitation, and rainfall.

This study discusses the use of multiple linear regressions to estimate or predict rainfall. It can assist farmers in making proper crop production decisions. In comparison to basic linear regression, the experiment and our multiple linear regression methodology exploit the right results for rain fall. The concept of regression can be implemented by calculating coefficient, slope and the considered climate data set either day, monthly or annual wise. As well as the performance of predicting the future values can be calculated by using multiple linear regression algorithms. The natural incidents may not possible to stop and cannot estimate in a efficient and accurate manner.

In general by using the concept of future estimation concept or events or values there may be a scope to minimize lot of problems. In this project we have implemented the simple regression methodology, multiple regression and we predicted the values, the multiple regression error rate also less when comparing with simple linear regression. Finally concluding that multiple linear regressions can be better than simple linear regression. By considering vapour pressure value as a dependent variable with other values as independent we successfully implemented the simple linear regression method multiple linear regression.

This is the concept of prediction but not in a accurate manner because we know that climate factors changes due to different reasons and impacts on it. 2.8 Comparative Study of Regression Models Towards Performance Estimation in Soil Moisture Prediction In this paper the result of experimental scenario for different machine learning regression techniques to predict the soil moisture. Soil moisture is an important part of the hydro-logical system since it depicts the normal conditions in a small volume of soil. It is critical to build an effective irrigation management system for this reason since an accurate prediction of soil moisture can save water and energy. They have employed supervised machine learning algorithms to forecast soil moisture.

A training data set is used to train the algorithm in supervised learning, and then testing and validation data sets are used to test the taught system. Regression models are a method that involves a targeted variable that must be predicted from a set of known predictors. Multiple linear regression is a statistical analysis algorithm for determining a link between multiple independent variables and a dependent variable. This algorithm they've used can help us in implementing a similar algorithm in our project. Once the relationship between the independent and dependent variables is established, all information about the independent variables may be obtained and used to make more accurate and influential predictions about the effects.

Furthermore, this research examines various machine learning regression algorithms. 2.9 Crop Water Requirement Prediction in Automated Drip Irrigation System using ML and IoT This research paper proposes to automate the time-consuming process by developing a microcontroller-based system for automatic smart drip irrigation that can accurately forecast the amount of water required by the crop. With the use of sensors, the amount of water that should flow through drip irrigation will be predicted by taking into account the weather, soil, and crop conditions. The goal of this research is to determine the exact amount of water that needs to be delivered to the crops.

Water is usually delivered to the crop when the conditions sensed by the system achieve the targeted conditions, and therefore water is given at such intervals in many techniques. The system, according to this proposal, first detects meteorological conditions and soil moisture using sensors such the soil moisture sensor and the DHT11 sensor. The data from these sensors is then sent to the Arduino Nano via serial communication. The ML code is executed on the Arduino Nano, which is connected to the local machine, and these sensor inputs are used as input parameters. The output is monitored when the code has been computed. The technologies used in this paper simulate how the system forecasts the required amount of water for irrigation of each crop by taking into factors like weather, soil and crop conditions.

When there is a lot of data and a lot of dependencies, machine learning is applied. The available facts must be used to make an accurate prediction. Moisture and temperature are important factors in deciding the amount of water that should be applied to the soil in this suggested system. In this proposed system there is moisture and temperature which play a crucial part in determining the water content that has to given to the soil. These parameters are measured along with soil moisture to predict an accurate output. Finally, in conclusion with this proposed system one can save manpower and water required to improve crop production which in the longer run increases the profit. 2.10

AI and IoT Based Monitoring System for Increasing the Yield in Crop Production Research is performed on a marigold plant to help detect and predict the most suitable conditions for optimum growth in this paper. Plant growth is monitored using an IoT-based monitoring system that measures humidity, temperature, soil temperature and moisture, and light intensity. Different sensors units, such as DHT11, LDR, DS18B20, Soil Moisture sensors, Noir camera, single-board micro-controllers, and Application Programming Interfaces, are used to collect data for plant growth. Different Machine Learning (ML) algorithms are used to further analyze the retrieved parameters.

The top methods for analyzing physical characteristics responsible for marigold plant growth were found to be Logistic Regression, Gradient Boosting Classifier, and Linear Support Vector Classifier (SVC). This paper provides sufficient information on the kind of sensors, hardware technologies and also software algorithms to be used in a project of similar calibre. By using data visualization, this study discovered the most beneficial settings for the marigold plant, and this trained model can then be used to identify the rate of growth of the marigold plant by simply providing it with the necessary environmental physical conditions. In the realm of artificial farming, this technology offers a lot of potential. All the sensors have been deployed in the field and scripted using C++ in Arduino IDE.

Json script is used to maintain the serial communication between Arduino Uno and Esp8266 Wi-Fi module. We have found the best favourable conditions for the marigold plant by data visualization and later on, this trained model can be used to detect the rate of growth of marigold plant just supplying it the environmental physical conditions. Further, Logistic Regression, Linear SVC and Gradient Boosting Classifier found to be the best fit algorithms with 83.33% accuracy. This technique has a great scope in the field of artificial farming. Not only we can detect the best favourable conditions for particular crops like millet, chillies, tea, coffee etc., but also we could prepare a dataset using IoT which could tell us the best suitable plant for a particular soil and climatic condition.

Chapter-3 Problem Statement Since our project is concerned with the field of agriculture, our solutions to the problems cannot be too expensive and cumbersome to use. Using small but smart devices that can communicate with each other and work in synergy is the goal of the Internet of Things (IoF). Machine learning is the best way to work towards complex issues while using the least amount of code and computing power. Hence, we will be using a combination of internet of things and machine learning to develop a low cost and effective real time monitoring system. Since weather patterns can change within an instant, we have to use technology that can collect data at regular and store it and also compute it in real time [1]. Certain crops are quite sensitive; hence irrigation has to be carried out in a precise manner.

This means using technology to gather information about the environment and then deciding how much water the cross need at the time. Some crops can be destroyed if they are watered extensively. To ensure this does not happen, we must adopt a way to predict if there will be rain and to what extent. This will help the farmers gauge what the irrigation situation will be in the future which in turn lead to better yield and harvest of the crop. Chapter-4 Objectives The first object of the project is to collect data. This is a vital step as the rest of the processes depend on reliable data. This has to be done with less hardware. Implementation of this project will be done in agricultural fields so the farmers must not feel it is too complicated to work with. This hardware must also produce as close to zero errors, if not then whole harvests will be destroyed due to these errors.

Hence this system must be effective at doing its job. The hardware components and the whole system itself will be low cost so as to not over burden the farmers. The hardware part of the project will mainly contain sensors that will be used as the monitoring system. This data collected from the sensors has to be sent wirelessly hence Wireless Sensor Network (WSN) will be used. The sponsor that will be used will be able to collect data like humidity, temperature, soil moisture, etc. Farmers can add more sensors that can capture other data as per their needs. To compute all this data, we will use Linear Regression. These algorithms will help with the prediction of rain. Depending on the farmer's needs, actuators can be used to perform certain actions based on the results received from the system. Chapter-5 Methodology 5.1

Design Goals The following are the design goals that are applicable to every application regardless of application domain, size or complexity. None the less, this project focuses on the following points for design goals � Simplicity as in UX/UI interface � Reliable data collection � Environment adaptable � Flexibility in Sensor node � Optimizing the sensor node � Ease of addition of sensor nodes � Storage of data safely � Ease access of data from anywhere in the world 5.2 Approach The total system is divided into 4 modules - Composing sensor nodes and data collection, creating sink node and master node and establishing communication between them, creating cloud storage and sending the data to cloud storage, finally battery management circuit for all sensor nodes 1. Composing sensor nodes and data collection � Sensor node is composed of sensors like soil moisture sensor, temperature and humidity sensor, rain sensor, etc.

� This is collected by a microcontroller called NodeMCU � The protocol used between them is one wire protocol 2. Creating sink node and master node and establishing communication between them � A sink node acts as a gateway. It collects data from sensor nodes using ESPNOW protocol and pushes it to master node � Sink node is composed of ESP8266 � The master node is composed of ESP32 and collects the data from sink node using UART protocol and sends it to Cloud storage using HTTP protocol 3. Creating cloud storage and sending the data to cloud storage � The cloud storage used is from google called �Firebase Real-time database� � It collects the data from Master node and stores it safely � It also displays the data in real-time and can be accessed from anywhere in the world 4. Battery management system for sensor nodes � Lithium-ion batteries of 3.7V, 2200mAh is used to power the sensor nodes � TP4056 is used to charge the batteries 5.3

Software Architecture Following are the software requirements for the proposed design: 5.3.1 Arduino IDE Arduino is an establishment that creates and produces single- board microcontrollers and microcontroller accoutrements for creating digital bias. It's an open- source tackle and software action. Its software is distributed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), allowing anybody to produce Arduino boards and distribute the software. Java was used to produce the cross-platform Arduino IDE, which is available for Microsoft Windows, macOS, and Linux. It has a law editor with tools for textbook copying and pasting, textbook relief, automated indenting, brace matching, and syntax pressing. It also offers straightforward one- click collecting and uploading tools for Arduino systems. Figure 5.1: Arduino IDE Logo 5.3.2 Firebase Firebase is a platform developed by Google to make mobile and web operations.

Save the data and attend it with the NoSQL pall database. Data is synced in real time across all guests and is available indeed when the app is offline. The data is stored as JSON and accompanied in real time with each connected customer. When you make a cross-platform app using the Apple platform, Android, and JavaScript SDK, all guests partake a Realtime Database case and automatically admit updates for the rearmost data. Because real- time databases are NoSQL databases, they've different optimizations and features than relational databases. The Realtime Database API is designed to allow only operations that can be performed snappily [17]. Figure 5.2: Firebase Logo 5.3.2 Python Libraries NumPy, which stands for Numerical Python, is a library conforming of multidimensional array objects and a collection of routines for recovering those arrays. Using NumPy, fine and logical operations on arrays can be performed.

It's a library conforming of multidimensional array objects and a collection of routines for processing of array. Pandas is an open- source Python Library furnishing high- performance data manipulation and analysis tool using its important data structures. In 2008, inventor Wes McKinney started developing pandas when in need of high performance, flexible tool for analysis of data. Using Pandas, we can negotiate five typical ways in the processing and analysis of data, anyhow of the origin of data - cargo, prepare, manipulate, model, and dissect. Python with Pandas is used in a wide range of fields including academic and marketable disciplines including finance, economics, Statistics, analytics, etc. Matplotlib is one of the most popular Python packages used for data visualization.

It's a cross-platform library for making 2D plots from data in arrays. Matplotlib is written in Python and makes use of NumPy, the numerical mathematics extension of Python. It provides an object- acquainted API that helps in bedding plots in operations using Python GUI toolkits. Matplotlib along with NumPy can be considered as the open-source fellow of MATLAB. Scikit-learn (Sklearn) is the most useful and robust library for machine learning in Python. It provides a selection of efficient tools for machine learning and statistical modeling including classification, regression, clustering and dimensionality reduction via a consistence interface in Python.

This library, which is largely written in Python, is built upon NumPy, SciPy and Matplotlib. 5.4 Hardware Architecture Following are the hardware requirements for the proposed design: 5.4.1 NodeMCU (ESP8266) (as Sensor Node and Master Node) NodeMCU is an open- source firmware with open- source prototyping board designs. The name "NodeMCU" is a combination of the word's" knot" and" MCU"(micro-controller unit). The Lua scripting language is used in the firmware. The firmware is erected on the EspressifNon-OS SDK for ESP8266 and is grounded on the eLua design. It makes expansive use of open- source systems similar as lua- cjson and SPIFFS. druggies must elect the modules applicable to their design and make firmware acclimatized to their requirements due to resource constraints. Figure 5.3: NodeMCU-ES8266 module Figure 5.4: NodeMCU-ESP8266-Pinout Figure 5.5:

NodeMCU-ES8266-Pin Functions A circuit board configured as a binary in- line package that integrates a USB regulator with a lower face- mounted board containing the MCU and antenna is generally used for prototyping. The design was originally grounded on the ESP8266's ESP- 12 module, which is a Wi- Fi SoC integrated with a Tensilica Xtensa LX106 core, which is extensively used in IoT operations. 5.4.2 � ESP32 (As Sink Node) ESP32 is a low- cost, low- power system- on-a-chip microcontroller family with erected- in Wi- Fi and binary- mode Bluetooth. The ESP32 series is powered by a Tensilica Xtensa LX6 binary- core or single- core microprocessor, a Tensilica Xtensa LX7 binary- core or a single- core RISC- V microprocessor, and includes erected- in antenna switches, RF balun, power amplifier, low- noise admit amplifier, pollutants, and power- operation modules. Espressif Systems, a Shanghai- grounded Chinese company, created and developed the ESP32, which is manufactured by TSMC using their 40 nm process.

It's the ESP8266 microcontroller's successor [15]. Figure 5.6: ESP32 Module 5.4.3 Temperature and Humidity - DHT11 Sensor The DHT- 11 Digital Temperature and moisture Detector is a simple and affordable digital temperature and moisture detector. It measures the girding air with a capacitive moisture detector and a thermistor and labors a digital signal on the data leg (no analogue input legs demanded). The power force for the DHT11 is 3-5.5 V DC. When the detector is powered up, don't shoot any instructions to it within one second in order to pass the unstable status. For power filtering, connect a 100nF capacitor between VDD and GND. Figure 5.7: DHT11 Sensor TABLE I: PINOUT OF DHT11 SENSOR VCC DC Pin (3.3V - 5V) Data Outputs both Temperature and Humidity through serial Data GND Ground Pin 5.4.4 Rain sensor Rain sensors are a type of switching device used to detect precipitation.

It acts like a switch, and the principle of operation of this sensor is that the switch normally closes when it rains. Basically, this board contains a nickel-plated line and operates according to the resistance principle. This sensor module enables humidity measurement via analog output pins and provides digital output when the humidity threshold is exceeded. Figure 5.8: Rain Sensor Module Here, PCBs are used to collect raindrops. When it rains on the board, it creates a parallel resistance path calculated by the op amp. This sensor is a resistance dipole and only shows resistance based on humidity. For example, when it dries, it has higher resistance, and when it gets wet, it has less resistance. Figure 5.9: Rain Sensor Module control TABLE II: PINOUT OF RAIN SENSOR AO Analog Output Pin DO Low/High Output Pin GND Ground Pin VCC 5V DC Pin 5.4.5

Soil Moisture Sensor The mechanism of the soil moisture sensor is very simple. A bifurcated probe with two exposed conductors acts as a variable resistor whose resistance changes depending on the water content of the soil. This resistance is inversely proportional to the water content of the soil. A typical soil moisture sensor consists of two components. 1. Probe: The sensor contains a bifurcated probe with two exposed conductors that are inserted on the ground or elsewhere to measure moisture content. As already mentioned, it acts as a variable resistor whose resistance changes with soil moisture. 2. Module: The sensor also includes an electronic module. The module produces an output voltage depending on the resistance of the probe and can be used with the AO pins.

The same signal is sent to the LM393 precision comparator, digitized and made available on the DO pin. Figure 5.10: Soil Moisture Sensor Module TABLE III: PINOUT OF SOIL MOISTURE SENSOR AO Analog Output Pin (Analog signal between the supply value to 0V) DO Digital Output Pin (Digital output of internal comparator circuit) GND Ground Pin VCC DC Pin (3.3V - 5V) 5.5 System Architecture System Architecture is a conceptual model that defines the structure, behaviour, and more views of the system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviour of the system. 5.5.1 Functional Block Diagram Figure 5.12: Block Diagram of Proposed Design Our project works on a wireless sensor network (WSN), in which a sensor node gathers information from several sensors such as humidity, temperature, and soil moisture content.

A sink node, also known as a base station or master node, gathers data from several similar sensor nodes and delivers it to a cloud database where it may be analysed and displayed to make predictions or automate and manage real-time machinery. Figure 5.13: Block Diagram of WSN network To interact with users through the internet, a sensor node made up of several sensors is linked to a sink node. Our technology has the advantage that the sink node is not reliant on the quantity of sensor nodes, making it simple to expand the kind or number of sensors without altering the sink node. For the communication portion, there is a proprietary protocol called ESP-NOW which is based on IEEE 802.11 vendor-specific action frames. The sensor node may become inactive once the data has been transferred from it.

The data transfer operation will repeat once the user-specified time interval has passed. With this protocol, the sensor node uses just 170mA while transmitting data and 80mA when it is idle. The sink node is made up of a master receiver (NodeMCU), which collects data from sensor nodes and transmits it via UART to an ESP8266-01 Wi-Fi module, which then sends the data to the internet. Having these two distinct systems has the benefit of keeping the system very modular. The master receiver may still receive data from the sensor node without any change if this WSN-based data logger has to be put in a remote location without access to the internet.

We send the information to a local server for the needed calculation on-site and display the real-time data to the user over a local network. As shown in the block diagram figure, the overview of the circuit diagram of WSN based data logger system. Our sensor nodes consist of three sensors and a microcontroller. A single battery is used to power the circuit. Although sensor node can contain any sensor the user wishes, we have used DHT11 sensor, rain sensor and resistive moisture sensor. 5.5.2 Circuit Diagram Figure 5.14: Circuit Diagram of Proposed System The circuit diagram is as shown in the figure above. It consists of all the necessary elements depicted along with their pin numbers and connections. Figure shows three sensor nodes each equipped with the set of necessary sensors and the nodeMCU for transmission of the data. The sensor data is then sent to the sink node wirelessly using the ESP-NOW protocol.

The sink node acts as a gateway, collecting all the data from all the sensor nodes and sending it to the master node using the UART protocol. The master node is configured to relay this data to the cloud database using HTTP protocol. The database used is Google Firebase. Using the database, we can access the data through any computer and run ML algorithms to predict of there is rain in the near future. Figure 5.14: Circuit Diagram of Proposed System 5.5.3 Pins Used The pins used in various sensors and in microcontrollers are as indicated in the table below. It shows where we are supposed to make connections for the proposed system to work. They are important part of any project. They also indicate the physical or hardware connections of any project. If anything is not working according to expectation, this is the primary inspection for debugging. Wrong physical or hardware connections might even damage the components used.

Following the pins used: TABLE IV: PINS USED TO INTERFACE THE COMPONENTS Sensor Node: Pins used Soil Moisture sensor A0, GND, VCC Rain sensor D0, GND, VCC Temperature and humidity sensor (DHT11) Data, GND, VCC NodeMCU (ESP8266) GND, VCC, A0, D6, D7 TP4056 GND, VCC, 0+, 0- Sink Node (ESP8266) D6, D7, VCC, GND Master Node (ESP32) D6, D7, VCC, GND 5.6 System Implementation The basic flow of the system implementation is as written below. It simplifies the complex method of implementing system to few steps. Where, one step taken at a time can impact the outcome. This flow can be modified according to need as well. Step1: Start Step2: Collect data from sensors and send to the microcontroller on the sensor node Step3: That microcontroller sends the data to sink node Step4: Sink node collects data and pushes the data to master node Step5: Master node sends the data to Google Firebase, Real-time database Step6: ML algorithm is used to predict rain by using these data set values Step7: ML algorithm predicts weather there will be rainfall or not Step8: Stop Step9: End. 5.6.1

Working Sensor Node: Sensor nodes are the ones which contain sensors that the farmer needs to collect data from agricultural field. These sensor nodes are more in number and are placed at the required distance. It is composed of Sensors like soil moisture sensor, temperature and humidity sensor, rain sensor, etc. they are collecting data using a protocol called �One wire protocol�. It works very similar to I2C protocol but it is simpler to use. Figure 5.15: Sensor Node of the WSN data logger system These sensor nodes have a microcontroller which is used to collect data from sensors and send it to the sink node. This microcontroller is NodeMCU or ESP8266. They can be operated by AC power source and by batteries. Sink node: The function of sink node is basically to collect the data from all the sensor nodes connected and send it to master node. The sink node is collecting all the data from sensor nodes using ESP-NOW protocol.

Because the ESP NOW protocol only functions amongst the family of ESP created by Espressif, NodeMCU is utilised as a microcontroller. The ESP8266-01 is used in conjunction with the microcontroller to transport the acquired data from the microcontroller to the firebase database. Although NodeMCU has integrated Wi-Fi, we still utilise an external Wi-Fi module since we can quickly convert to other communication types [GPS, LORA, ZIGBEE, etc.] because we employed UART connection between the microcontroller and the Wi-Fi module in the event that Wi-Fi communication is not available.

Master Node: The master node contains ESP32 and its function is to collect data from Sink Node using UART protocol and to send the same data to a cloud storage using HTTP protocol. The sink node and the master node are physically connected using the Rx and Tx pins and hence, they are together. Figure 5.16: Sink Node and Master Node As shown in the figure, the sink node and master node are physically together and their function is to collect data from sensor node and to send it to cloud storage, Firebase from Google. A sensor node may be designed to provide data at any interval, and because the master is always powered, it can receive data from any sensor node at any time. Cloud database for data storage Figure 5.17: Snapshot of cloud storage showing the data in real-time The data collected has to be stored to do any further analysis with it. For storage, we have used could storage.

This has many advantages like it can be accessible all the time; it can be accessed from anywhere, etc. Firebase, a google cloud data storage provides data storage facilities along with further expansion into running AI/ML algorithms to it. It also provides real time viewing of data collected. This is a service provided by Google to collect, store and monitor data. Google has created a platform called Firebase for building mobile and web applications [7]. Since Firebase makes it simpler to host websites and create mobile applications using an existing database, it was picked. The user may easily and securely log in using their email to access their statistics thanks to Firebase Authentication. This is also readily expandable to support additional login ways, such as Facebook, phone, or any other. The data stream originating from the sensors is kept in a real-time database.

Any change in the data will be immediately displayed on the dashboard because the database is real-time. 5.6.2 Dataset The dataset in which ML algorithm will be performed is collected from a third-party website i.e., Kaggle. The dataset shown in below figure has many fields. The dataset is structured and labelled which clearly indicates that the type of Machine learning is Supervised learning. Figure 5.18: Dataset Used 5.6.3 ML Algorithm The Machine learning model for predicting rain at a particular time is going to be done by the linear regression model. Linear regression is the method of plotting data points onto a graph. Linear regression can be diverse which has multiple independent variables used as input features and simple linear regression which has only one independent or input feature.

Both linear regressions have one dependent variable which can be forecasted or predicted based on the input features. The multivariate linear regression was employed in this study to predict the dependent variable, daily rainfall amount, which was dependent on a number of environmental variables or features. Using the known environmental factors as input, the supervised machine learning technique of linear regression is utilised to forecast the unknown daily rainfall amount. Multiple explanatory or independent variables (X) and a single dependent or output variable, indicated by Y, were used in the multivariate linear regression. Hence, the general equation of the multiple linear regression is given as: Figure 5.19: Machine Learning Algorithm Where xiT is transpose of xi the input or independent variable, ? is regression coefficient, ?i is error term or noise, Yi is a dependent variable. 5.6.4

Source Code # Cleaning the data # import the libraries import pandas as pd import numpy as np # read data in pandas dataframe data = pd.read_csv("bangalore_weather.csv") # drop (delete) the unnecessary columns in the data data = data.drop(['Events', 'Date', 'SeaLevelPressureHighInches', 'SeaLevelPressureLowInches'], axis=1) data = data.replace('T', 0.0) data = data.replace('-', 0.0) # Save the data in a csv file data.to_csv('bangalore_final.csv') # import the libraries import pandas as pd import numpy as np import sklearn as sk from sklearn.linear_model import LinearRegression import matplotlib.pyplot as plt # read the cleaned data data = pd.read_csv("bangalore_final.csv") X = data.drop(['PrecipitationSumInches'], axis=1) Y = data['PrecipitationSumInches'] Y = Y.values.reshape(-1, 1) day_index = 798 days = [i for i in range(Y.size)] clf = LinearRegression() clf.fit(X, Y) inp = np.array([[74], [60], [45], [67], [49], [43], [33], [45], [57], [29.68], [10], [7], [2], [0], [20], [4], [31]]) inp = inp.reshape(1, -1) # Print output print('The precipitation in inches for the input is:', clf.predict(inp)) print('The precipitation trend graph: ') plt.scatter(days, Y, color='b') plt.scatter(days[day_index], Y[day_index], color='r') plt.title('Precipitation level') plt.xlabel('Days') plt.ylabel('Precipitation in inches') # Plot a graph of precipitation levels vs no of days plt.show() x_f = X.filter(['TempAvgF', 'S0ilMoisture', 'HumidityAvgPercent', 'SeaLevelPressureAvgInches', 'VisibilityAvgMiles', 'WindAvgMPH'], axis=1) print('Preciptiation Vs Selected Attributes Graph: ') for i in range(x_f.columns.size): plt.subplot(3, 2, i+1) plt.scatter(days, x_f[x_f.columns.values[i][:100]], color='b') plt.scatter(days[day_index], x_f[x_f.columns.values[i]] [day_index], color='r') plt.title(x_f.columns.values[i]) # plot a graph with a few features vs precipitation to observe the trends plt.show() 5.6.5

Flowchart The complete flow of process of the proposed methodology is shown in below figure. Firstly, an accurate dataset is being collected. There are various websites where users upload datasets which can be used by other users for the sake of analysis. Our dataset is collected from Kaggle. Data is then cleaned to obtain the necessary data for the Machine Learning. Then a specific Machine Learning Algorithm is applied onto the cleaned dataset to produce required information from it. Here, linear regression is used in order to predict the future attack with respect to the data units and their encryption level. Figure 5.12: Flow Chart of Proposed Methodology Chapter-6 Experimental Results and Discussion 6.1 Results The result of the experiment performed showed good potential to be adapted in real world. The data obtained after performing the experiment is as tabulated below.

TABLE V: TABULATION OF COLLECTED DATA ON TESTING Display of collected data Node - 1 Day - 0 At 4:00pm At 5:00pm At 6:00pm At 7:00pm Temperature (in 0C) 25.3 24.0 23.7 22.4 Humidity (in %) 43 45 56 67 Moisture (in %) 87 84 81 79 Rain (0 or 1) 1 0 0 0 In "Table V," the ambient temperature, humidity, soil moisture content and rain fall are all tabulated. On the first day, the information was gathered from sensor node 1 (day 0). To note the time at which this data was obtained, the sensor inserts a timestamp. Data can be received from the other nodes and forwarded to the master node in a manner similar to how the data from the first node is tabulated. The designed firmware is extremely dynamic and can adapt to numerous nodes.

The master node can manage an increase in the number of hardware nodes or the addition of new sensors to an existing sensor node with little to no modifications to the firmware. Due to the usage of Firebase Hosting, which is accessible from anywhere in the globe, the user has a lot of flexibility when accessing the data. Figure 6.1: Machine Learning Algorithm Implemented The following figure shows precipitation level which tells us about the rainfall with the help of other paraments. The size of the data set collected from the dataset for this paper was appropriate to use the machine learning algorithms called multivariate linear regression that can estimate the daily amount of rainfall in the region.

This technique can demonstrate the degree to which each environmental factor affects the daily rainfall intensity. 6.1.1 Quality Metrics The important parameter in implementing such systems practically would be battery life management. The battery needs to be charged and recharged every now and then to maintain the sensor nodes. Few experiments were performed to measure the current consumption of sensor nodes while being used and while in idle state. While performing the experiment, the data was transmitted once per hour from the sensor node to the master node. The device's current consumption was measured to be 170mA for 40ms, during data transmission and 80mA while it was idle. The battery can theoretically power the sensor node for 435.356 hours, or around 18 days and 3 hours, if we can include a light sleep mode into the NodeMCU that shuts off the Wi-Fi. Here, the current consumption drops to 10mA.

The circuit can manage to do better with a little bit more optimization, and by adding a deep sleep mode to NodeMCU, the battery life can be increased even further. Table---: Tabulation of current consumption in various states of Sensor node State of the Sensor Node Current Consumed While transmitting the data 170mA In idle state 80mA When in Sleep Mode (No Wi-Fi connectivity) 10mA The battery can be prolonged by other methods like selecting a battery with higher wattage or by keeping lesser number of sensors, etc. 6.2 Applications � Agriculture is the backbone of India. One of the fundamental aspects that we can improve in agricultural field is by getting more data from soil, atmosphere, plants, etc accurately.

� By collecting more data, we can apply machine learning and prediction algorithms to figure out the amount of fertilizer, water and other manures required for crops to get better yield. 6.3 Advantages and Disadvantages 6.3.1 Advantages � Wireless Sensor Network is reliable and fast. � When offline, data is stored and uploaded when Wi-Fi connection is established. � Data packets are not lost. � All the nodes are battery operated, hence portable. � Sensor nodes are customizable. � Wireless Sensor Network (WSN) based data logger system for collecting data accurately from agricultural field. 6.3.2 Disadvantages � Battery has to be monitored and recharged. � To increase area coverage, more hardware is required. Chapter-7 Conclusion and Future Scope 7.1 Conclusion Agriculture plays an important role in every human's life. It is one of those fields which require dire need of technology especially when India's population is growing.

Hence, our project aims to collect, monitor and store data accurately. It is further subjected to ML to predict rain to demonstrate how collected data can be used further. The project also aimed in being flexible to be able to adapt in real life agricultural field. To increase the yield of agricultural corps, implement smart farming, collect data from the agricultural land efficiently, store and process, various research papers were referred. This paper presents the literature review of various methods and technologies that can be used to implement a system which achieves this goal.

Various methods for data logging, effective usage of hardware along with aiming cost effective methods were found out. Steps to be taken for collection of data with minimum hardware should be achieved. Data transmission is also one of the interested fields; where the collected data is sent to cloud. Formation of Wireless Sensor Network was studied in many papers. Different approach of implementing and practical problems that could be faced was presented in the paper. Research conducted to overcome these problems is also discussed in the paper. Domination of WSN as a practical, implementable and cost-effective method over other data collection methods was discussed. Transmission and storage of data were also discussed as a part of the problem.

In this area, after the reception of data, effective system has to be implemented to store it. If not, the data would be of no use. This system had to be discussed because the farming area might pose unforeseen problems because of network issue. To overcome these issues, referring few research papers has been vital. As the final stage, the collected data has to be used in effective ways. In this stage, the system becomes very flexible according to the needs of the user. This system is then used to predict rain or other agricultural variables to help achieve the goal of smart farming and data driven agriculture. Few research papers are discussed here in this field as well. 7.2 Future Scope Data Collection is aimed to be optimized in this project. This can be taken forward as demonstrated before; the collected data can be subjected to further AI/ML algorithms to implement useful strategies in agricultural field.

Or it can also be used to predict rain, storm, and etc. events. The project can also be developed further and additional physical layers can be added to shield the modules like sensor node and master node from environmental harshness. This also becomes necessary as the modules will be subjected to harsh environment for long duration of time. By protecting the modules from environmental changes, the life of modules can be increased along with their durability and effective performance. The design of the system can also be optimised in many ways. For example, in increasing the distance coverage, instead of ESP-NOW protocol, LoRa modules and communication can be used as it gives up to three miles (five kilometres) in urban areas, and up to 10 miles (15 kilometres) or more in rural areas (line of sight). Other improvement as a future scope would be to include an actuator which controls the watering pump according to ML rain prediction. This would make the system completely automatic, reducing the work of the farmer while taking care of the crops.