EARLY WARNING FOR PRE AND POST FLOOD RISK MANAGEMENT

FINAL REPORT

Mohamed Fazil Mohamed

IT18003406

BSc (Hons) in Information Technology Specializing in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology

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Mohamed Fazil Mohamed

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Dissertation Submitted In Partial Fulfillment Of The Requirements For The Bachelor Of Science In Information Technology

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1 DECLARATION

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2 ABSTRACT

Flooding and landslides have been a very dodgy situation in Sri Lanka where many parts of the country are flooded for the slenderest rain. Due to such incident's loss of property, damages to agriculture activities, loss of business, and loss of lives etc. are some incidents which takes place due to the flooding situation.

To address these situations, we have developed a Pre and Post warning structure to minimize the shattering devastation that could be caused. Since this solution provides very critical information which includes real-time weather monitoring using IoT, Data Mining based weather predictions and a crowdsourcing data gathering mechanisms and third-party API utilization on current weather.

The sensors used in the ESP32 based IoT designed meteorological conditions measuring device were used to measure and store data about the increasing of the water level, temperature, humidity, and the rainfall intensity. The accumulated information will be represented on the Mobile Application and the Web application dashboards for user's use. We have used the database (Live) appropriately to store and transmit the gathered data which is used for the other models in this system.

To facilitate the non-subscribed users of this application an SMS methodology is used which will provide live weather information upon users' requests which could be based location wise.

Keywords: Real time weather monitoring, IoT(Internet of things), Data mining, ESP32, Temperature, Humidity, Increasing water level, rainfall intensity, Crowdsourcing, API, SMS.

3 ACKNOWLEDGEMENT

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I would also like to express gratitude my parents for all the backing they gave me with no anticipation of a compensation. Their constant help, support and tolerance have made my life full of success, and I am glad for everything they have done.

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6 LIST OF ABBREVIATIONS

Abbreviation	Description
API	Application programming interface
AI	Artificial Intelligence
CPU	Central processing unit
DB	Database
GPS	Global Positioning System
IDE	Integrated development environment
IoT	Internet of Things
IP	Internet Protocol
JSON	JavaScript Object Notation
MAC	Medium Access Control
ML	Machine Learning
OLED	Organic Light-Emitting Diode
PCB	Printed circuit board
RTC	Real Time Clock
SDLC	Software Development Life Cycle
SIM	Subscriber identity module
SMS	Short Message Service
SQL	Structured query language
SSD	Solid-state drives
TCP	Transmission Control Protocol

WLAN	Wireless Local Area Network

7 INTRODUCTION

Natural disasters are one of the main threats we as Sri Lankans face in our day to day lives. Among the natural disasters flooding is once the main threats faced by humans. Even for a smallest rain a risk of flooding is anticipated because of various points. Such as due to constant climate changes taking place in the atmosphere, due to human activities such as constructions & landfills etc.

Due to such situations, we have proposed an "EARLY WARNING FOR PRE AND POST FLOOD RISK MANAGEMENT" system to overwhelmed them. This research we will be providing warnings by monitoring the rainfall and the water levels and providing data of other weather components. By this our main ambition is to provide a flood risk management method which will be useful to reduce the economic loss to the state and human.

7.1 Background Study

Flood tracking and Management

With the gradually changing Environment pattern flooding has been one of the main key tragedies which we got to face presently. Due to this devastating situation damages to infrastructure, agronomy is enormous. Unfortunately, loss of lives is also one of the issues humans faces.

Some areas in the country are more disposed to flooding than the other locations, due this reason inaugurating a flood warning and monitoring system will be able to collect perilous and key information which could be used to inhibit impairments and the loss of lives.

IoT device-based weather monitoring system

An efficient weather & flood monitoring and warning system should comprise of regular and reliable data collection of the rainfall, increasing of the water level. With a help of an IoT device which is more cost effective and productive than a routing monitoring by using personals.

Developing a live flood monitoring and tracking system should contain 3 main factors.

1. Data Collecting
2. Data administering
3. Data distribution

To process on the data gathering method we have used Rain drop detection sensor and the HC-SR04 distance monitoring sensor which will be used to monitor the increasing water level of a certain location.

For data processing we have used an ESP32 microcontroller which consists of a Wi-Fi embedded module which is beneficial in performance more than assembling an external Wi-Fi module to the monitoring device.

These data gathered with the help of the sensors will be disseminated to the users in 3 main methods such a mobile application, web application & SMS.

SMS based weather data providing

This methodology was used to approach all the stakeholder of this system such as some user will not be able to access this system due various issues such as not able to meet the hardware and software requirements etc. due to this reason, we have designed a method for such users also to receive weather information upon their request via SMS.

7.2 Literature Review

With an oscillating change in the atmosphere relentlessly there are damages to the people who resides in contrary areas. Also, there are some areas where the people aren't notified about the consequences precisely in their areas, due to the rapid adaptation of weather conditions regularly [1]. In the current world, knowing the live environment has become a greatest challenge because of the obstacles IoT encounters when it comes to assessing the live meteorological conditions [2]. Also, fields such as constructions, agriculture, manufacturing etc. also causes assorted defies in the nature's condition [2]. Since all of us are aware, agriculture performs a crucial role in the country's Economy. Internet of Things(IoT) could be exploited to watch and control numerous devices distantly with the support of sensor network which has the capability of detecting, processing, and transmitting the information to a cloud. A cloud is a service which provides a proficiency of advance reckoning, storing, and producing information in a more precise format. From the cloud service these data could be made available on various platforms such as mobile applications, web applications etc. [3]. The internet acts as the heart of revolution while playing a dynamic responsibility in reliability, productivity, and quick communication from information from the device to the cloud contrarywise. IoT extends a wide range of connectivity of objects with miscellaneous procedures and properties of applications for acquiring a complete machine to machine collaboration [4]. Applying all the best practices and modern technologies in IoT the public and the relevant officials will be able to overcome majority of the intense weather conditions and be prepared for any circumstances.

A Weather monitoring system could be considered as a tool which could be used to calculate the weather factors based on the environmental situations. A weather station also knows as a weather monitoring system is used to improve the consistency of the monitoring surface. Monitoring the change of the weather situation should be done in regular intervals since these weather data gathered by the help of various sensors will be vital for various industries[5].

Internet of Things is known as an innovative cost-effective tendency in the current world. IoT being the link for all the devices which are rooted with sensors and microcontrollers which is used to interconnect with each other to switch data. This achieves the intention of identifying, perceiving, following, discovering, and administrating entities [6].

IoT is a technology which has become more advance in the within a short period of time where there are 1000s of smart electronic devices connected with this technology. IoT is a technology which consist of physical objects which has the electronic technology and software incorporated in it. Sensors, devices, microcontrollers assist the user to obtain information in a timely, precise, and accurate manner. The key theory in IoT(Internet of things) is used to interconnect numerous electronic devices and sensors together and assemble a weather monitoring device which could be used to monitor weather data factors and retrieve them and could be distributed to various other platforms. This gathered information could be stored in any cloud service too which could be used for data processing and analyzing [7].

The fast-developing technology compromises advance solutions to develop innovative structures than the past. Which also offers advance and new sensors which has the capability of performing advance functions which has diminished power consumption than the previous. The environment is and highly advance system with massive number of factors which are interconnected with each other. A miniature change in a single parameter causes a major change to our day to day lives.

A station is considered as a smart station when it’s compromised with microcontrollers, sensors, and numerous hardware’s and software’s. These modules need to be self- examining and self- defensive. Applications are categorized as two methods such as Event detection and spatial process [8]. The assembled sensor devices are responsible to detect the meteorological data such as temperature, humidity, rainfall, and the increasing water level.

The usage of this IoT technology plays a key role to assist the agriculture industry in terms of increasing the cultivation and reducing the workforce. Many researches have

approached the agriculture industry with the help of the IoT technology which could help to improve the cultivation etc. [9].

Monitoring weather data factors offline is not feasible and practical in the current world especially during a particular dangerous envy and serious conditions. In this evolving technology of radio technology, IoT has given a substantial remark in the world. This remark has led to implement smart IoT weather monitoring systems across the world [9].

Handling a massive amount of data, discovering the secrete configurations and converting those data into various from of information which was gathered with the help of these sensors and transforming them into user consumable information has been important task currently [10].

Currently due the handling of a large amount of data has become a challenge IoT has become a major support and strength together with machine learning to have a secure and analyzed data from this gathered information.

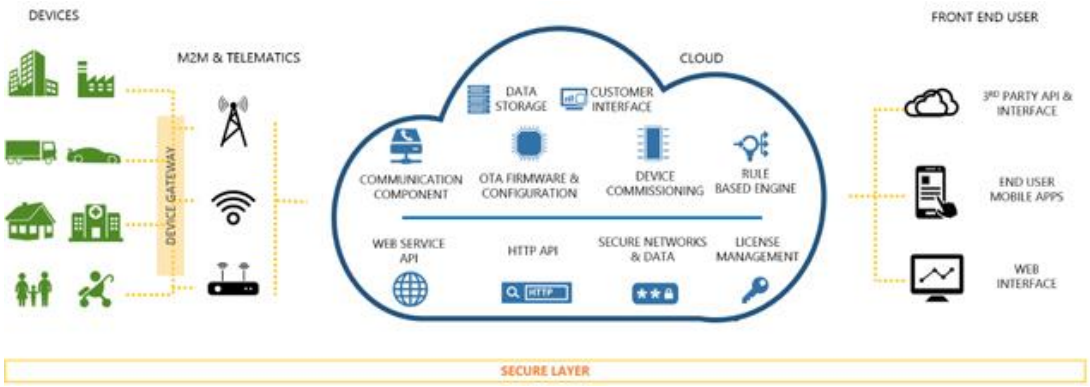


Figure 1: Internet of Things structure

7.3 Research Gap

Considering some past research studies with related to same field of weather monitoring using IoT has being done. Considering [6] this study has a fully functional weather information monitoring device in place with majority of the weather data monitoring sensors included. Having many sensors included in a IoT weather monitoring device is more productive than having many devices to monitor each aspect of the environment [11]. Some studies have gathered data with the assistance of an IoT device and previewed on a web application despite of any verification or validation of data[12].

Deliberating some research paper available and studies conducted understood that the stability of device could be improved more by reducing the number of sensors used and use other substitutes which are available in the industry. Such as use a Wi-Fi embedded microcontroller, temperature and humidity monitored by 1 sensor module etc. also, having a live data transmission is also one of the key factors in live weather data monitoring which studies have emphasized on improving. Also, approaching the users who could not consume weather information too is an area which need to be focus and to be implemented. The propositioned IoT device monitoring and approaching non subscribed users' system comprise of the following.

Research Studies	Use of IoT sensors		Other weather data monitoring sensors	Approach to non-subscribed users
	Ultrasonic Sensor	Rain Drop Detection sensor		
[6]	×	✓	✓	×
[12]	×	✓	✓	×
[7]	×	×	✓	×
[11]	×	×	✓	×
[13]	×	✓	×	×
Proposed System	✓	✓	✓	✓

Table 1: Comparison of the proposed model with the existing studies

This proposed system has the ability to monitor the main key factors of the environment which could be used to conduct a prediction for flooding and extreme weather conditions. These gathered information will be verified and validated with the other models in this system such as ML, AI, and crowdsourcing technologies. Since this information will be consumed by the authorities for various instances validation and accuracy is the main key feature of this system. Also, at times due to intense weather situations stakeholders might not be able to access the system with their usual platform, to avoid such disruption we have a SMS base weather providing system which any user could receive weather information from any location where an IoT weather monitoring device is place upon request.

7.4 Research Problem

Flooding is catastrophic situation in Sri Lanka due various reasons. Once a flooding situation takes place the arising of water level happens swiftly. In this case the damage and loss are not countable. To avoid such incidents and be prepared well in advance we have designed a live monitoring system. This designed device will be monitoring the factorial change of the climate and will be transmitting this monitored information to the system in regular intervals.

Flood tracking and monitoring is also a part of disaster management whereas taking precautions in a timely manner are some key points. To perform such actions in a timely manner technology and information should be freely available at any given time. Due such issues authorities and the public aren’t able to take the necessary precautions.

To cater to such hitches, we have implemented a system solution which could be assistive to fulfill those loopholes. By this solution management of flood risk and receiving weather information in a timely manner. Implementation of an Iot device is one of the key aspects in this system as in the all the live weather information will be monitored via this device. The other main problem which we came cross other studies

are the efficiency of data transmission from the IoT device to the system. For this we have used a Wi-Fi module which rooted into the microcontroller which give me efficiency and productivity to the device.

At times due extreme weather conditions there are instances where users aren't able to access the system due to internet failures etc. during such situation also if any user of authorities would need to access weather information of a particular locations. To complete this aperture, we have a solution implemented whereas the user could request the weather information via SMS which is freely and accessible at most instances. User could make a request of the location they willing to receive via SMS and the relevant details of that locations will be shared via same mode.

When proceeding on the implementation of this research study the above-mentioned solutions are to be more studied and examined with the help of the industry expert to ensure that this research cater to the correct problem and provides a suitable solution to it.

8 RESEARCH OBJECTIVE

8.1 Main Objective

Designing and implementing a smart device to gather live weather data information, transmitting gathered information to the applications in a precise manner, and reaching out to the users who aren't able to access this system due to various reasons.

8.2 Specific Objective

To accommodate the above-mentioned objective the below subobjectives needs to be completed accordingly.

1. Desinging and Implementing a smart device to monitor the weather factors

A live weather monitoring device plays major role in terms of live tracking and sensing. To complete this challenge, we have designed an IoT based device which consists of weather data monitoring sensors such as temperature, humidity, rain fall, and increasing water level. To increase the performance and durability of the device we have designed this device on the PCB board which increases the performance and durability and the feasibility of the device.

2. Transmission of device sensor data

The designed IoT device will be monitoring the weather data factors continuously and this detected information will be transmitted to the system in regular interval. To fulfill this method, we have used an ESP32 module which has a Wi-Fi module embedded to it. Which also helps to increase the performance of the device instead of adding additional models to the device.

3. Reaching out to the non-subscribed users

Reaching out to every stake holder is one of our primary tasks as in this system will be providing vital information which could be consumed by everybody and every authority. To achieve this objective, we have designed a SMS based weather information providing system. Incase if a stakeholder isn't able to access our

application (Mobile/Web) they are still able to receive live weather information depending on the availability of the IoT device in that location.

9 METHODOLOGY

Before manufacturing and designing this weather monitoring device a deep study was done on Internet of Things(IoT) on its operations and functions and a way to design a PCB board which will also bring a feasible structure to the weather data monitoring device.

This developed early warning system has the capability and the ability of having the below functions,

1. Detection of Temperature & Humidity.
2. Detection of the intensity of Rainfall.
3. Detection of the increasing Water level.
4. Transmitting weather data information to the users via SMS on request.

This designed weather monitoring device will be playing a major role in this project as in many live weather data factors will be gathered by the help various types of sensors which are unique for their responsibilities, where these gathered data will be used for various models in this project.

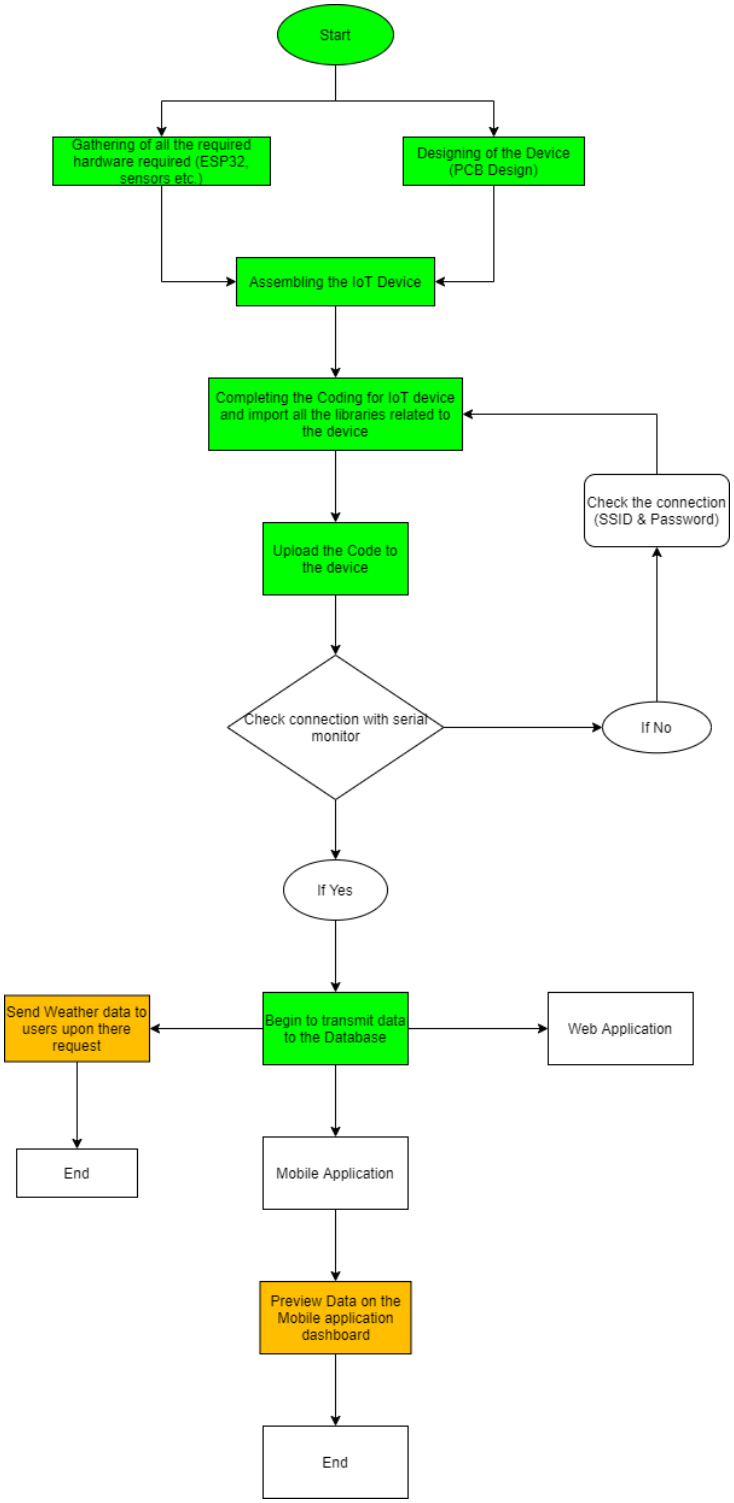


Figure 2: Flow diagram of the IoT Device

9.1 System Overview

In this designed IoT aided weather censoring structure, an ESP32 assesses 4 factors by exploiting the sensors. They are, DHT11 Sensor, which is used to monitor the temperature and Humidity, AJ-SR04T sensor which is used to monitor the increasing of the water level, Rain Drop Detection sensor and a DS1307 Clock RTC Module which will provide a precise time and date which is used to note the readings of each respective sensor.

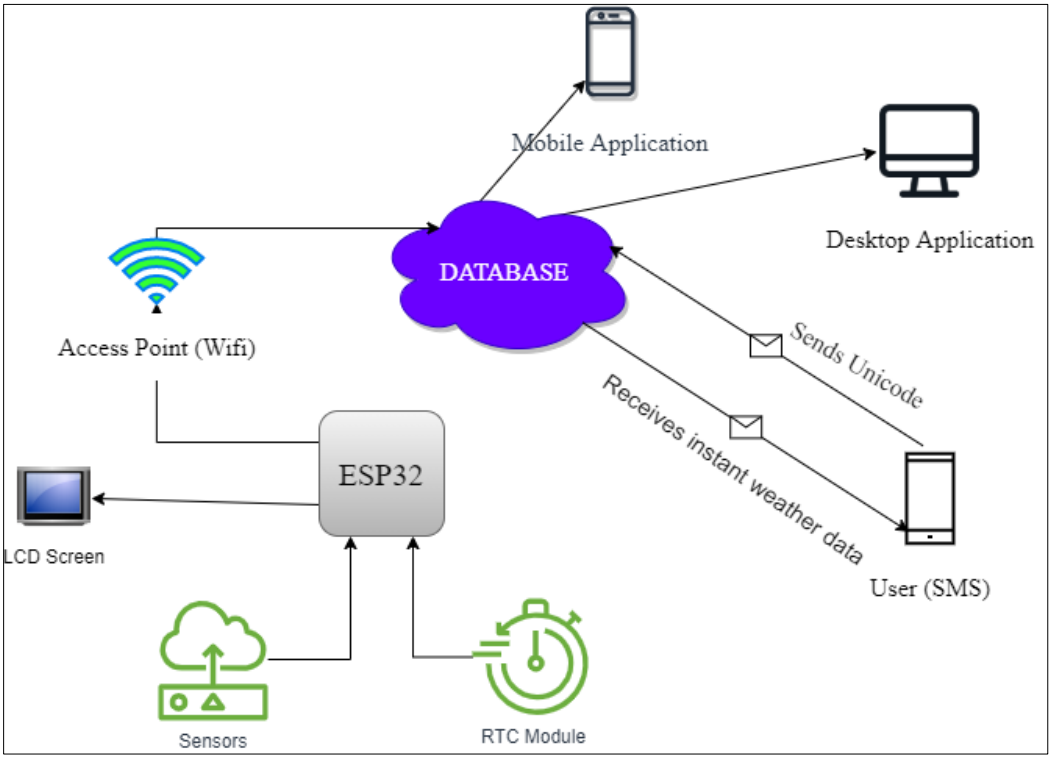


Figure 3: System Overview

When it comes to the perspective of usage some users may use our mobile application/Web site some may not use due to various reasons. But we will still be providing a solution for such users to get details via our system. This will be done where the user will have to send a request to our system via SMS and the user will be able to get limited important details related to weather data via the same mode.

9.2 Component Overview

Under this section we will be discussing all the components we have used to make this project a success.

9.2.1 ESP32(Wi-Fi module)

The ESP32 Wi-Fi module is a low cost & open-source software and hardware development environment which is used in the Internet of Things (IoT).

Figure 4: ESP32 Microcontroller

An ESP32 is programmable with various programing languages like micropython, Mongoose, Lua, Circuit Python, and Arduino software. In this project we have used the Arduino IDE to code the functions of the IoT device and C as the language.

The below figure will give an overview of the pins available in the ESP32 for a better understanding.

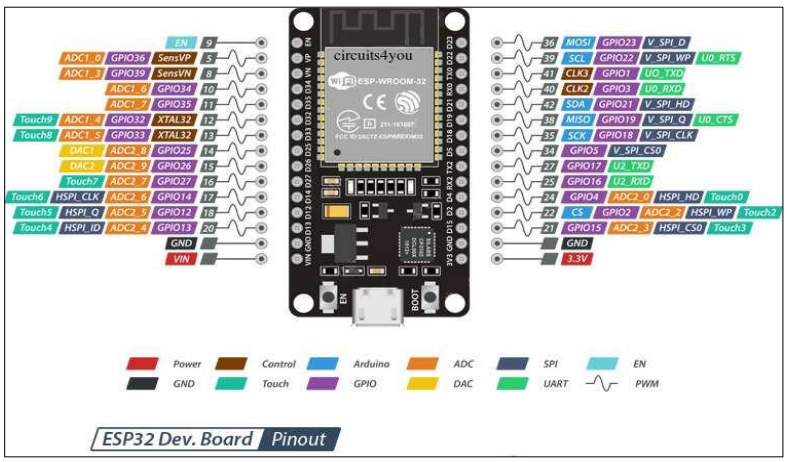


Figure 5: ESP32 Pinout Diagram

This device operates under network control of TCP/IP protocol, and Wi-Fi Direct condition which is meant that the ESP32 could contact majority of the Wi-Fi Routers which is used under the client mode.

ESP32 Main Features

- Microcontroller: Xtensa LX6 microprocessor.
- Operating Voltage: 2.2 to 3.6V .
- Input Voltage: 7-12V .
- Digital I/O Pins (DIO): 16 .
- Analog Input Pins (ADC): 15
- Flash Memory: 4 MB
- SRAM: 320 kib
- Clock Speed: 80 Mhz
- Wi-Fi: IEEE 802.11 b/g/n

9.2.2 dht11(temperature & humidity sensor)

DHT11 sensor is a low-cost digital reading sensor which could determine the temperature and the humidity of the nature. The monitored factors are sent data through the digital signal pin to process the data. This sensor also mainly focuses on the time break which will also affect in the accuracy of the data reading.

DHT11 Specifications:

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3ma (measuring) 60ua (stanDBy)
- Output: Serial data
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90%
- Accuracy: ±1°C and ±1%

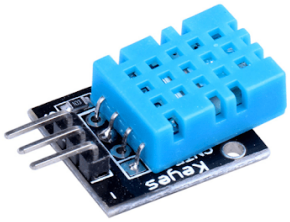


Figure 6: DHT11 Sensor Module

9.2.3 HC-SR04 Ultrasonic distance sensor

This sensor will be used to monitor the increasing of the water level without having a direct contact with the water body. This sensor monitors the distance based on the concept of “Time to Fly” where the speed of sound is used to calculate the distance between the sensor and the level.

AJ-SR04T Distance Sensor Specification

- Input Voltage: 5V
- Current Draw: 20mA (Max)
- Digital Output: 5V
- Working Temperature: -15°C to 70°C
- Sensing Angle: 30° Cone
- Angle of Effect: 15° Cone
- Ultrasonic Frequency: 40kHz
- Range: 2cm - 400cm

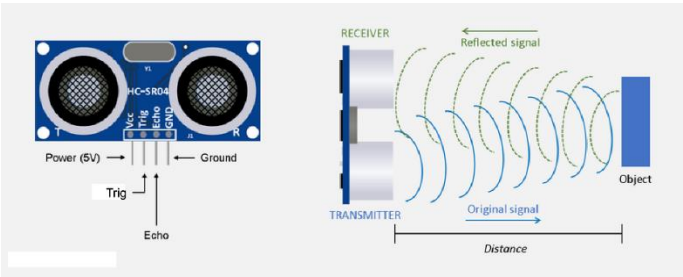


Figure 7: HC-SR04 Sensor reading methodology

Figure 8: HC-SR04 Ultrasonic Distance Sensor

9.2.4 Rain drop detection sensor

This board simply contains nickel coated lines which functions as a resistant. This sensor can monitor the moisture level through the analog pins and once the maximum of the moisture exceeds the data will transfer through the digital pin.

This sensor's resistance increases when its dry and consumes more voltage whereas when water Is contacted with those nickel lines the resistance is reduced and the use of voltage reduces.

Rain Drop Detection Sensor specifications

- Adopts high quality of RF-04 double sided material.
- Working voltage 5V.
- Output format: Digital switching output (0 and 1) and analog voltage output AO.

Figure 9: Rain Drop Detection Sensor

9.2.5 DS1307 RTC module (Real Time Clock)

RTC modules are used in many electronic projects to maintain and have an accurate date and time recording. There is a coin cell (CR2032) used which will avoid the time resetting even though the ESP32 has gone for a complete reset or power is removed. This module could function for nearly 7 Years without any external 5V power supply with an CR2032 coin cell.

DS1307 Specifications

- Real-Time Clock (RTC) Counts Seconds, Minutes, Hours, Date of the Month, Month, Day of the week, and Year with Leap-Year. Compensation Valid Up to 2100
- 56-Byte, Battery-Backed, General-Purpose RAM with Unlimited Writes
- I2C Serial Interface
- Programmable Square-Wave Output Signal
- Automatic Power-Fail Detect and Switch Circuitry
- Consumes Less than 500na in Battery-Backup Mode with Oscillator Running
- Optional Industrial Temperature Range: -40°C to +85°C
- Available in 8-Pin Plastic DIP or SO

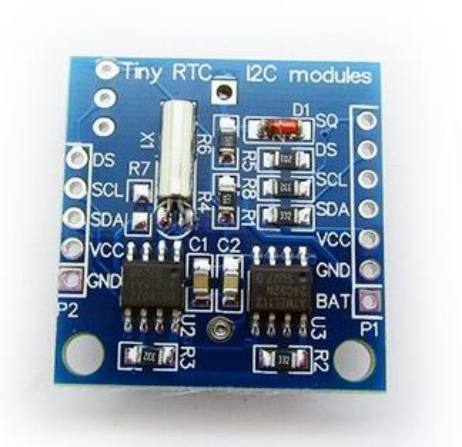


Figure 10: DS1307 RTC Module

9.3 Development process

The SDLC(Software Development Life Cycle) model is a method used for designing, developing, Testing software's in the industry. The SDLC cycle identifies a method to improve the excellence of the system and the overall process. This model is designed to ensure that a quality delivery is done to the customer and exceeds the customer requirement and it's completed on the time and within the budget.

Figure 11: Software Development Life Cycle

For us to succeed in our main goal of this project we need follow some processes accordingly to ensure that the standard is set to a quality standard. We must bring into

consideration that the issues and threats we faced to conduct research in this field. We have identified the solutions which could be used to solve the issues mentioned in the initial stage of this research, do a comprehensive study of the solution proposed, maintain a good time range which will suit us to conduct this research within 1 year period. This project “Pre and Post Flood Risk Management” is developed based on the SDLC model for a better and quality product.

9.4 Requirement Gathering and Data Collection

There are many proposed and developed IoT based weather censoring structure which is used to monitor the live weather data and transform those data into information. To make our study more detailed and accurate we have done detailed study in this field by gathering all the requirements and the information accordingly.

9.4.1 Requirements specification

- Functional requirements

  A functional requirement is known as the functions the software must perform. Which is also known as input, functions & output. It could be a computation, data management, business procedure, user collaboration, or any other functionality which describes what function a system could perform. Functional requirements could capture the behavior of the system which also consists of services, functions, and the task the system should perform. This current study the requirements are listed below,

  1. Sensing weather related data through the sensors
  2. Passing the gathered data to the DB
  3. Sending weather data information vis SMS upon user request

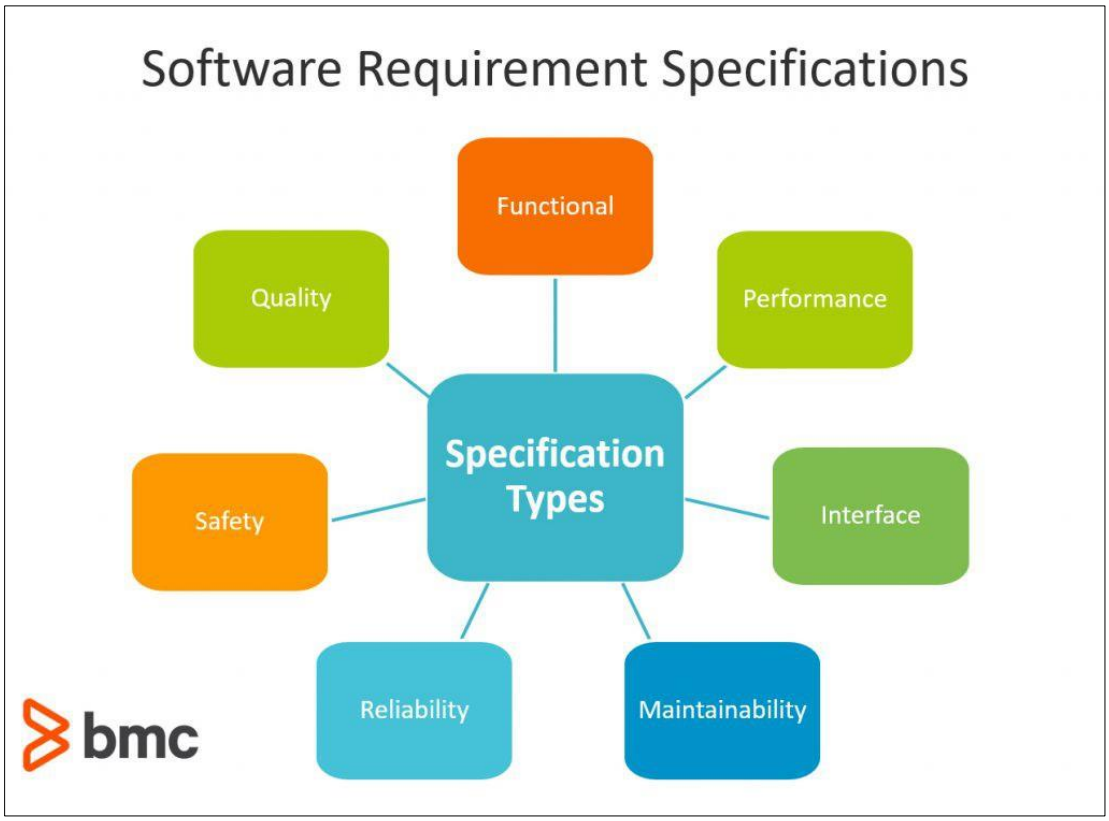


Figure 12: Software Requirement Specification

- Non-functional requirement

  The quality of the system is represented under the non-functional requirement category as in there are many criteria's which are used to monitor the system process. This requirement is vital in order to certify the serviceability, efficiency of the software. By not meeting the non-functions requirement will lead to issues in the system and user satisfactory.

  1. Taking less time to pass IoT gathered data to the DB
  2. Security of the system
  3. Privacy of the system
  4. The speed of the data extraction from the DB to the mobile/web interface

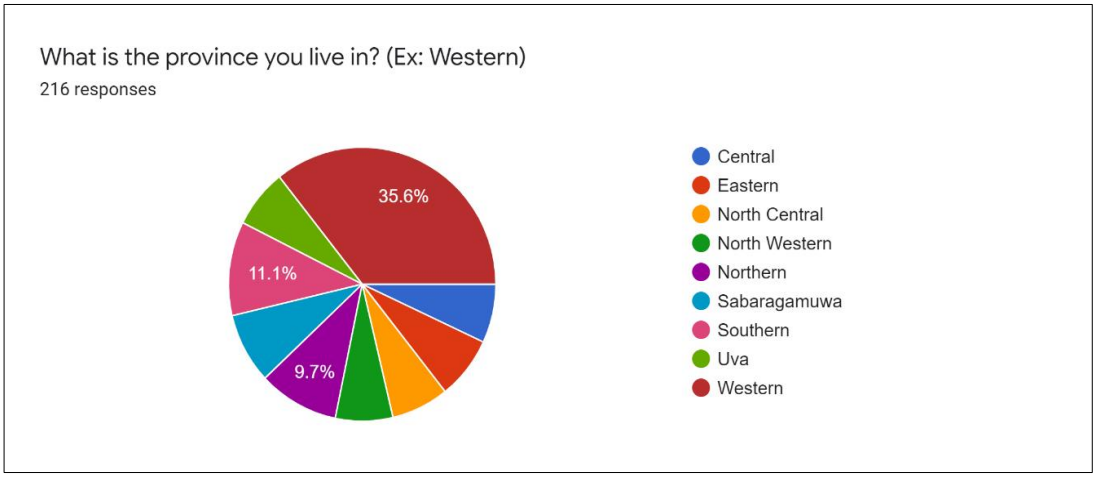
9.4.2 Data collection

A method of collecting qualitative and quantitative information is knows as Data collection. The Data collection should be done on a particular variable with having an aim of assessing the results or collecting actionable perceptions. A Good Data gathering requires a clear process to ensure that the gathered data is spotless, dependable, and consistent.

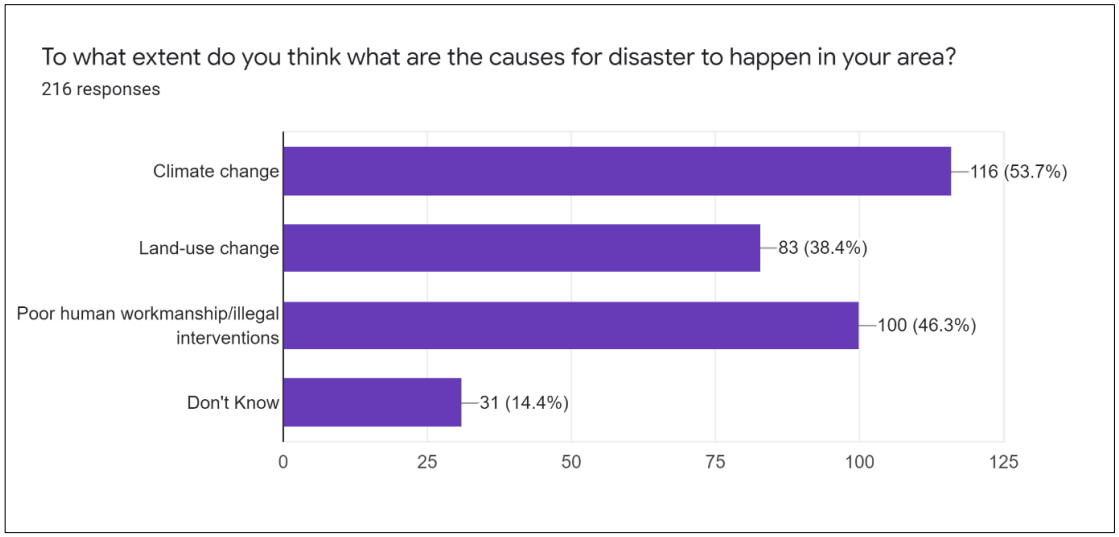
Determining that process could be problematic, it consist of taking a note of the objectives, identifying the requirements, deciding on the method and the mode of Data collection, and structuring a data collection scheme that produces the most needed information for our research.

By using the most suitable data gathering methodologies (Updated, newly developed) and with a clearly defined guideline you could minimize the errors and risk of the gathered data.

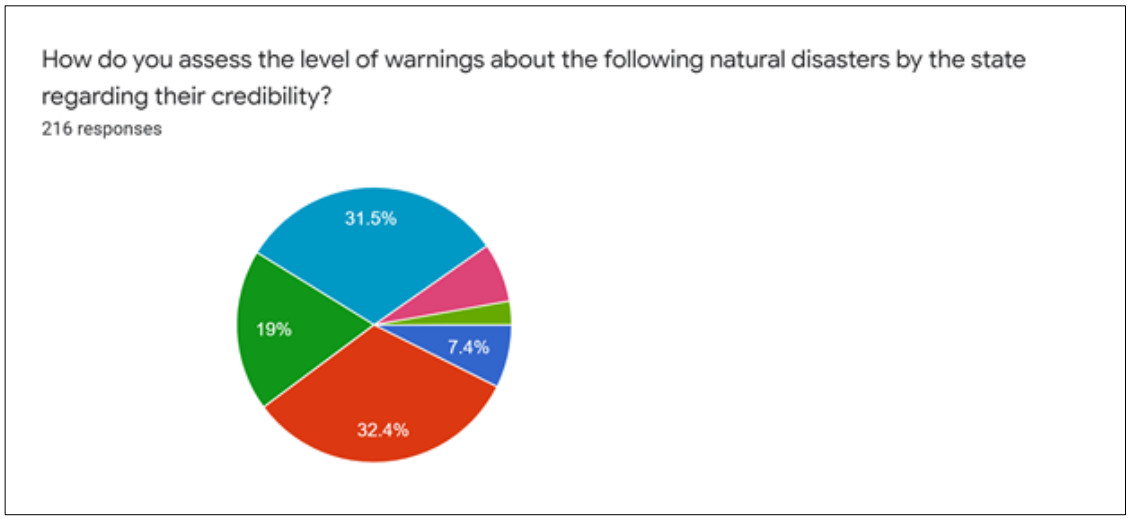
We have used Google Forms as one of our platforms to gather information of the Weather situations and the conditions of people resided at various locations in the country so that we could identify the locations most the people are affected of the flooding situation and other weather conditions.



From the above provinces most, affected province is identify as the Western province due to various reasons such as Climate change, Poor human workmanship/illegal interventions, and bad usage of land. From the above-mentioned reasons Climate change is mainly due to the Urbanization in the western province.



Taking all these factors into consideration we did a study on what level are the citizens satisfied of the information and the warning system is currently in place with related to the weather conditions.



From the above chart you could see that 32.4% is dissatisfied of the information providing procedure currently available. Which means this is a point which also leads to damages and issues due to lack of information providing and reporting warnings in a timely manner. Considering all these issues we have designed a Pre and Post Flood risk management system whereas users will be able to get all the weather data factors such as Temperature, Humidity, Rain Fall intensity, and water level of a specific location. All these information which the users will consuming will be well validated, cleaned and verified data which they could count on for their day-to-day activities.

Also, to make our system more reliable and dependable we have gathered Historic Weather information from the Meteorology Department to train our prediction models and provide a prediction etc. We have used a new emerging method known as Crowdsourcing which will be getting inputs from the users on weather conditions. All these sections will be fed with live weather data which will be monitored with the help of an IoT device which is placed in secure and specific location.

9.5 Feasibility Study

Feasibility is known as practical scope to which a project could accomplish. Which also defines on how useful the designed system will be practical and how effective it will be to the company. A Feasibility study is done based on many objectives such as to explore if the software product will be accurate in requisites of elaboration, establishment, subsidy of project to the organization.

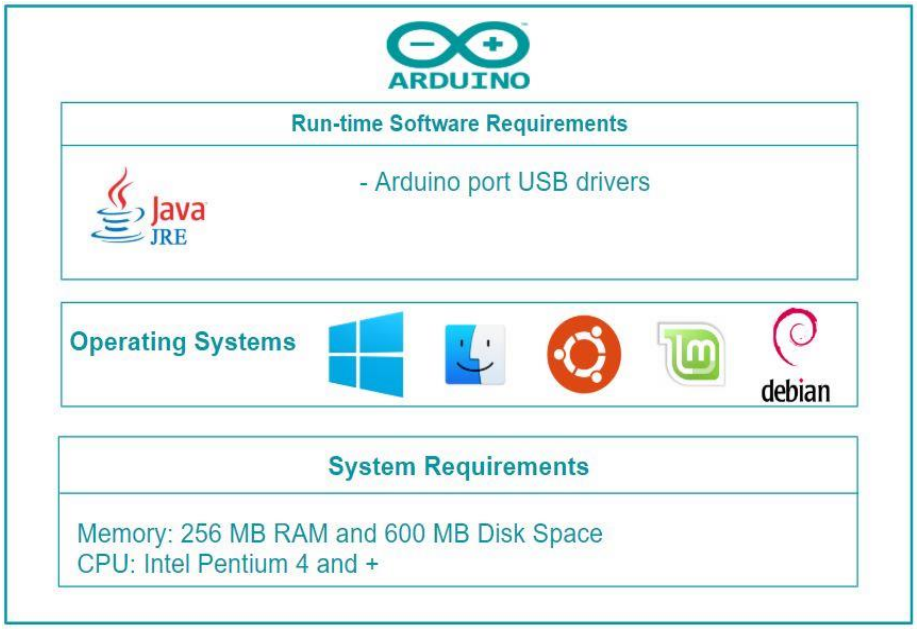
Weather conditions causing extreme damages to public property has increased day by day. Some is due to change of climate and the other is due to human activities and illegal constructions. By using this system public and the relevant authorities could be aware of the weather conditions as with the help of our prediction model, crowdsourcing data, IoT data a well verified and accurate weather data will be provided to them to take all necessary actions in a timely manner. This framework consists of ML, AI, IoT which are the emerging trends in terms of technology. Since this proposed system entails of a mobile application and web application the below tool was used to implement them.

9.5 Software and Hardware Specifications

9.5.1 Software boundaries

- Arduino IDE

  This is an open-source cross application which could be used in Windows, MacOS, Linux which functions are written in C and C++.This IDE has the capability to upload the written codes to any Arduino compatible boards with 3rd party cores and libraries.



- Altium designer

  Altium designer is a software which is used to design printed circuit boards (PCB) for electronical devices. We have used this software to design a PCB board for the IoT device which will also give a long durability and stability to the IoT device.

  System requirements

  1. Intel® core™ i7 processor or higher
  2. 16GB RAM

3. 10GB hard disk space
4. High performance graphics card (supporting DirectX 10 or better), such as GeForce gtx 1060/Radeon rx 470
5. Adobe® reader® (version xi or later for 3d pdf viewing)

- Android studio

  Android studio is a software which is used for android application development. This downloadable on windows, MacOS, Linux operating systems. Android studio provide a list of aspects which enriches the efficiency of the building android application.

  Features of android studio

  1. A flexible Gradle-based build system
  2. A fast and feature-rich emulator
  3. A unified environment where you can develop for all android devices
  4. Widespread of assessment tools and frameworks
  5. Built-in support for google cloud platform, making it easy to integrate google cloud messaging and app engine

- Vs code

  Visual studio code a known as light weight but powerful ide which could be run on windows, MacOS, Linux operating systems. This IDE has a built-in support for JavaScript, typescript and node.js languages. Apart from these it also has extensions to C++, c#, java, python, php, go etc.

- Gitlab

  Gitlab is a web-based DevOps tool which is also known as a repository manager. This software was developed by a Ukrainian developer known as Dmitriy Zaporozhets and Valery Sizov.

- Firebase

  This is a platform developed by Google which could be used to develop web and mobile applications. This is also categorized as a no SQL database program where data is stored in JSON format.

9.5.2 Hardware boundaries

For the development of this system below are the Hardware requirements required.

- Windows
    1. 64-bit Microsoft® Windows® 8/10
    2. X86_64 CPU architecture; 2nd generation Intel Core or newer, or AMD CPU with support for a Windows Hypervisor
    3. 8 GB RAM or more
    4. 10 GB of available disk space minimum

- MacOS
    1. MacOS® 10.14 (Mojave) or higher
    2. ARM-based chips, or 2nd generation Intel Core or newer with support for Hypervisor.Framework
    3. 8 GB RAM or more
    4. 10 GB of available disk space minimum
    5. 1280 x 800 minimum screen resolution

- Linux
    1. Any 64-bit Linux distribution that supports Gnome, KDE, or Unity DE; GNU C Library (glibc) 2.31 or later.
    2. X86_64 CPU architecture; 2nd generation Intel Core or newer, or AMD processor with support for AMD Virtualization (AMD-V) and SSSE3
    3. 8 GB RAM or more
    4. 10 GB of available disk space minimum
    5. 1280 x 800 minimum screen resolution

To run this application(Mobile app, Web app) below are requirements required.

- Web Application
    1. Windows 8, Windows 8.1, or Windows 10 or later
    2. Intel® Core™ i5 processor or later

- Mobile Application
    1. Android 9 or later

9.5.3 Communication boundaries

This entire system's communication relies on the internet for communication whereas the IoT device needs to have constant connectivity with a Wi-Fi connection to have smooth data transmission to the DB so that the other functionalities in the system could proceed smoothly. Also, the mobile application and the web application will also require a good network connection(Wi-Fi, Mobile Data) to access all the functionalities of this system.

The users who have not subscribed to our system and willing to use our SMS platform will have to an SIM from any network service provider to benefit this function.

9.6 Designs

The IoT device will be performing a major role in this project as in the users will be receiving live weather data through the Web application or the Mobile application with the help of the IoT devices positioned in various locations. These IoT devices will be having a GPS tracker assembled in the device which will help to have live location tracking together with weather information too.

The IoT device was designed on a PCB board to ensure long time durability, high performance, scalability and to have precise structure of the device.

Below shows the schematic design, PCB Layout, and the 3D view of the device of the designed IoT device.

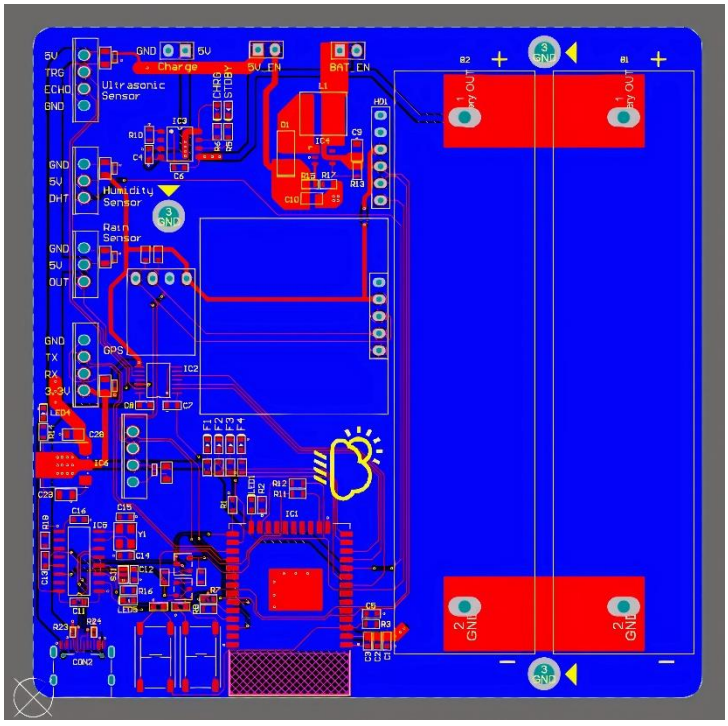


Figure 13: PCB Layout of the IoT Device

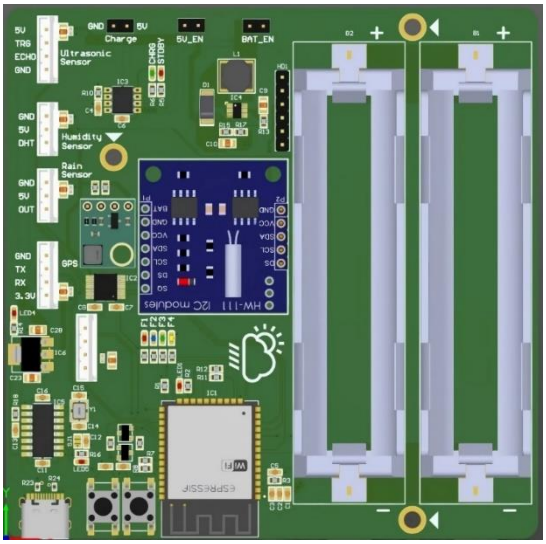


Figure 14: 3D view of the Designed PCB Board

The mobile application will have a dashboard to preview all the weather data factors(Temperature, Humidity, Rainfall intensity, Water level increase/decrease) gathered from the IoT device together with a graph view.

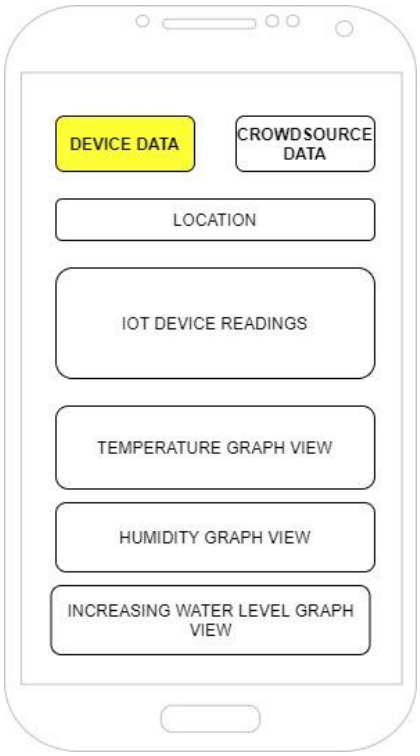


Figure 15: IoT Readings Dashboard Wireframe

The web application will also have a similar design to preview the IoT sensed weather data which will be beneficiary for both state and non-state members.

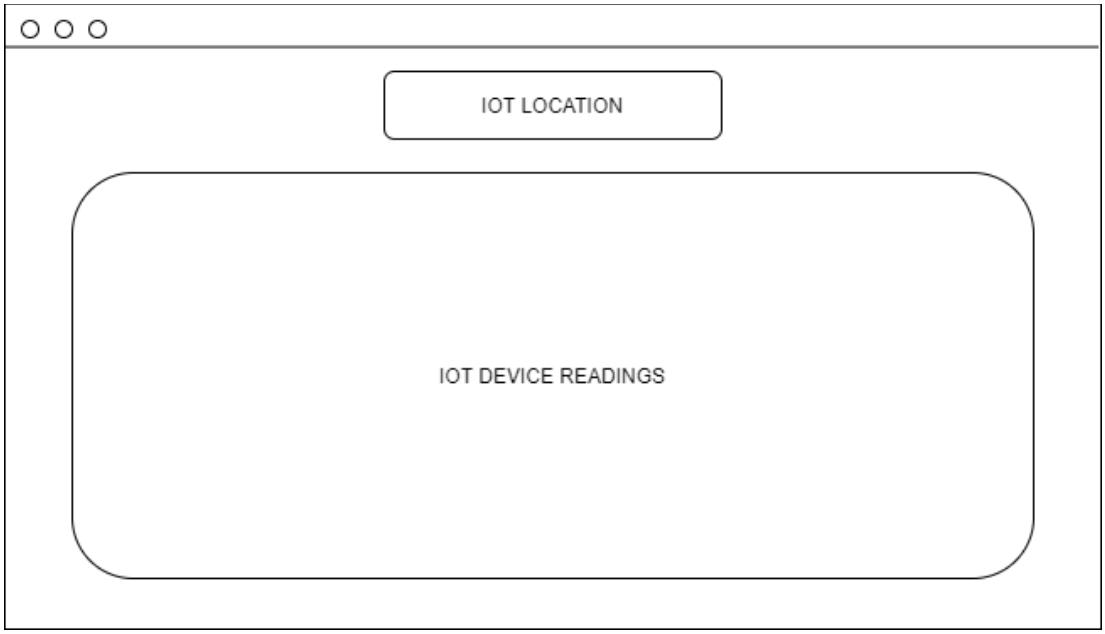


Figure 16: Web Application IoT device data preview wireframe

For the users who have is not a stakeholder of our system(Mobile app/ Web app) is still able to receive weather information upon users' request's location wise. Below is sample method on how they we receive weather data information once the users send a request to our system via SMS.

9.7 Commercialization

Specifications of the proposed device in the flood risk management system are as follows.

- Detecting Temperature, Humidity, Rain Fall intensity, and Water Level using sensors.
- Wi-Fi embedded microcontroller which is used for data transmission to the system
- Rechargeable battery

- Real Time clock module to receive accurate data and time of the sensor readings
- Used a PCB (Printed circuit board) to implement the weather monitoring device
- Enclosure added to the device

Therefore, the device will be useful to various parties who are interested in assessing weather conditions and risks of flood incidence. Further, this subject is relevant across the globe. Therefore, we can launch a global marketing strategy to commercialize the device. State authorities, meteorology/weather forecasting service providers (including TV and Radio Stations), commercial farm operators, travelers, community service providers and individuals will be some of targeted clients. Wi-Fi, researchable battery, and real-time clock will help promote more buyers across the globe. The device should carry a note explaining its uses or benefits in addition to technical details supported by online contacts/advice.

Accordingly, marketing strategy will focus on creating a network consisting of country agents, web sale agents, FB/social media advertising, etc. The online advisory service will be an essential element in sales service to attract and retain clients. Therefore, the objective of the marketing strategy should be to create wider demand and users across the globe rather than trying to reach immediate beneficiaries such as flood risk management authorities.

9.8 Testing and Implementation

9.8.1 testing

Internet of things(IoT) is a network that contains buildings, devices, and any other connected electronic devices. These interconnected devices link with each other to exchange data. There are 4 common mechanisms of a IoT system such as,

1. Sensor
2. Network
3. Application

4. Data Center

IoT is a technology which smartly connected devices communicate and transfer a huge amount of data and upload the same to the cloud.

IoT testing is a form of testing which is used to check the functionality and the performance of the IoT device. With the emerging technology in the world there us massive demand to create, access, use and share information from any electronic device. The drive is to afford greater vision and control, over numerous interrelated IoT appliances. Due to this reason IoT Framework testing is important.

9.8.2 Types of testing in iot

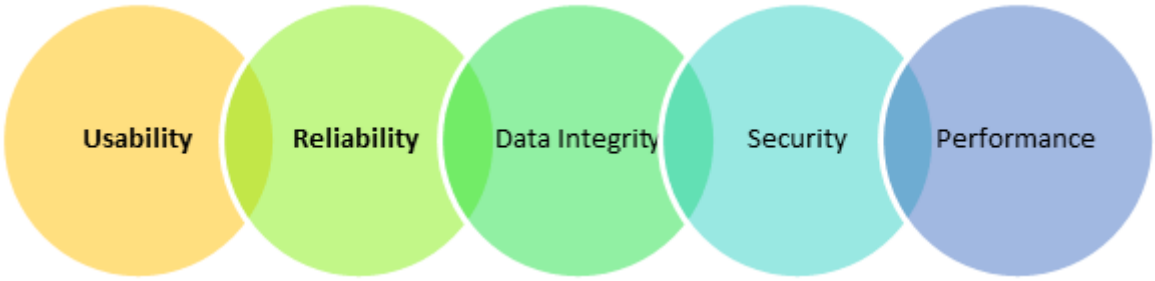


Figure 17: Types of testing in IoT

Usability testing

There are many devices designed by users which as different shapes and form of factors. Also, the designed devices too vary from each other. This is the main reason to have a usability testing in IoT.

Compatibility testing

With the developing world day by day IoT devices are being developed with various software and hardware configurations. Due to this reason, there is a huge number of

possible compatibilities. Due to this reason compatibility testing is compulsory to avoid issues and disruption happening when the device is in function.

Reliability and scalability testing

Reliability and scalability are an important part when designing an IoT environment which engages in various recreation of sensors by exploiting virtualization tools and technologies.

Data integrity testing

Data integrity testing needs to be done as IoT device will be engaged in a huge amount of data transaction with the data center and various other aspects.

Security testing

Since there is a huge data usage in the IoT environment there is a massive number of users involved in consuming them. Therefore, it is important to have a user authentication and validation to have secure data privacy.

Performance testing

The reason performance testing is different than the other testing methods is as in it has many components and terminuses involved. All these unique components and terminuses need to function without any deviation of speed, performance, or accuracy. Therefore, performance testing is one of the major testing methods which we need to use to ensure the durability and the scalability of the IoT device.

9.8.3 Sample test case conducted

Application Test Case 01

Test ID	**TC-A01**
Test case scenario	Checking if the IoT device is capable of synchronizing data in regular intervals
Entry Criteria	1. Minimum of 2 IoT devices needed 2. The device should be assembled in a method where is could be transfer data in a regular interval.
Test Procedure	1. IoT Device 1 & IoT Device 2 enlists to the network and a establishes a connection. 2. Check the DB if the data readings are transmitted within a regular interval. 3. Step 1 should be done repeatedly to ensure the connectivity to the network and DB is successful and data is passed within regular intervals.
Exit Criteria (pass)	IoT device 1 & 2 will send their network connection requests & DB connection request within a short time and transmit data to the DB in regular intervals.

Application Test Case 02

Test ID	**TC-A02**
Test case scenario	Checking the accuracy of the data readings of the IoT device in long and short intervals.
Entry Criteria	1. Fully assembled and functional IoT device. 2. IoT device being connected to the DB.

Test Procedure	1. Set the IoT device reading to the interval to 5 minutes. 2. IoT device connects to the network and establishes a connection to the DB. 3. Check the DB if the data readings are transmitted within given interval (5 minutes).
Exit Criteria (Fail)	Reading from the IoT device becomes irregular after a certain time.

Application Test Case 03

Test ID	**TC-A0**
Test case scenario	Checking the accuracy of the data readings of the IoT device in long and short intervals.
Entry Criteria	1. Fully assembled and functional IoT device. 2. IoT device being connected to the DB.
Test Procedure	1. Set the IoT device reading to the interval to 1 minute. 2. IoT device connects to the network and establishes a connection to the DB. 3. Check the DB if the data readings are transmitted within given interval (1 minutes).
Exit Criteria (Pass)	IoT device data transmission to the DB stays constant.

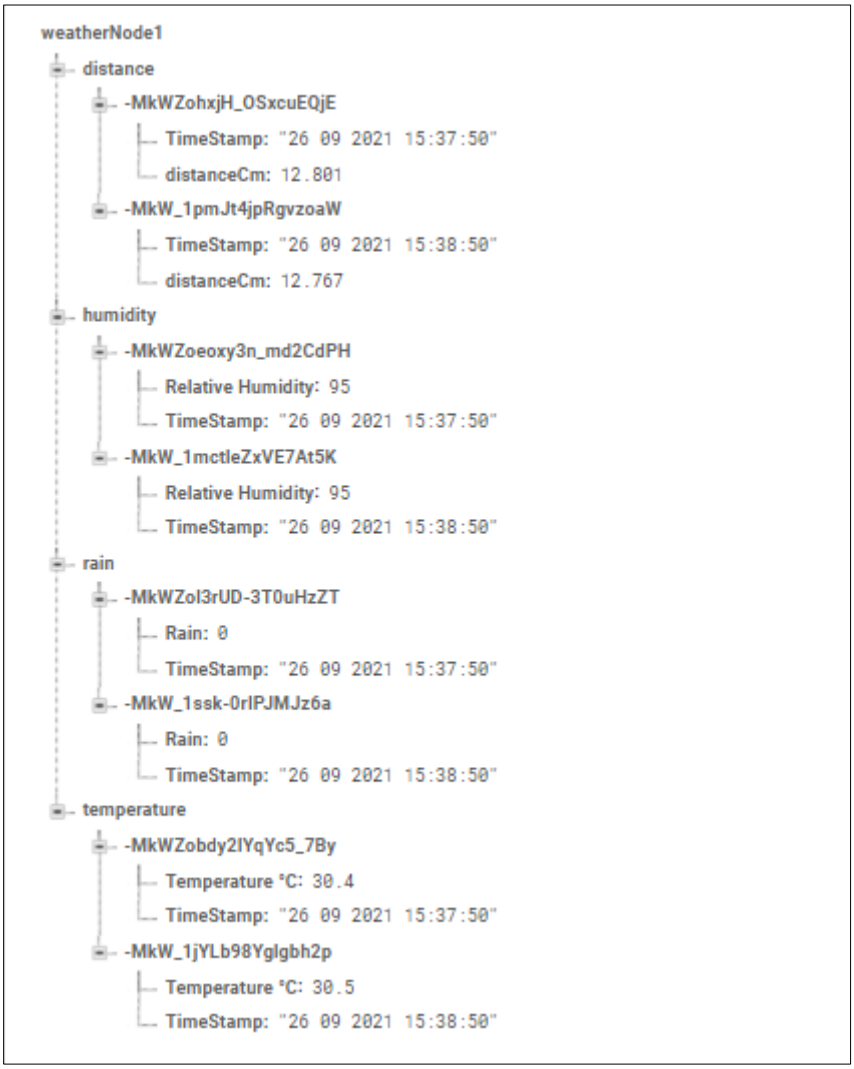


Figure 18: Database of the IoT device

9.8.4 implementation

This proposed and developed framework was developed as a Mobile application and a Web application. Where the main stake holders of the web application are supposed to be the state officials of the government authorities. The mobile application is mainly aimed towards the non-state officials which will be beneficial for their day-to-day routings. Also, the SMS based weather information portal is open to both state and non-state officials for their day-to-day use.

IoT device and the implementation

The IoT device sketch was initially designed by using an online tool which helped us to have a clear idea on the wiring system the IoT device will have to go through, for the sensors to functions properly.

Below is the sketch circuit design.

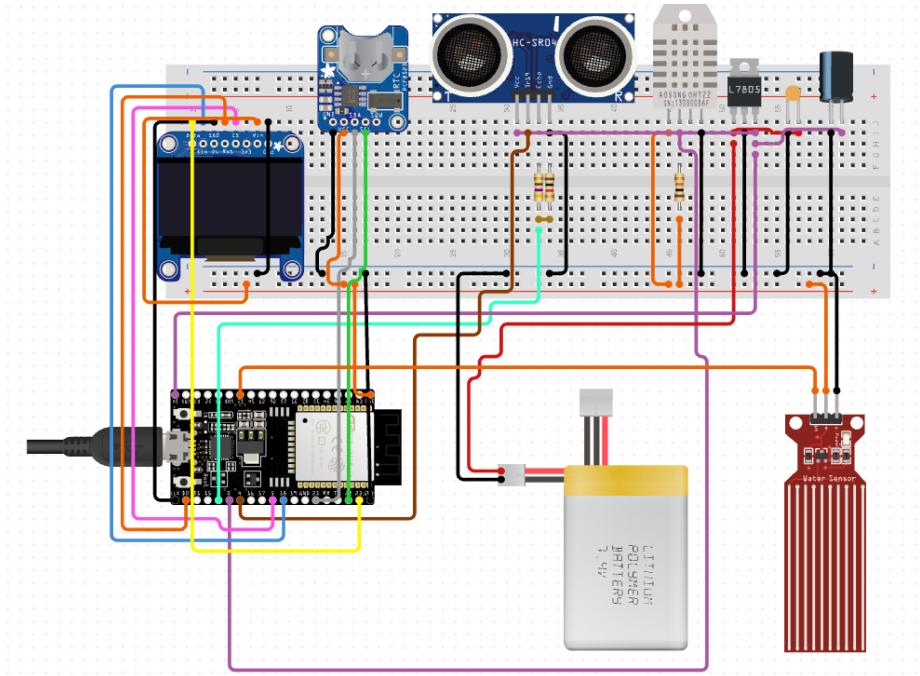


Figure 19: IoT device circuit design

To ensure a long use and a better accuracy and scalability of the device we have designed a PCB board for the IoT device whereas all the sensors, Power supply etc. Is directly embedded to the board. By having such precise structure on the device, the durability and scalability of the device will also increase and have a better function in the device.

Below is a schematic design of the designed IoT device

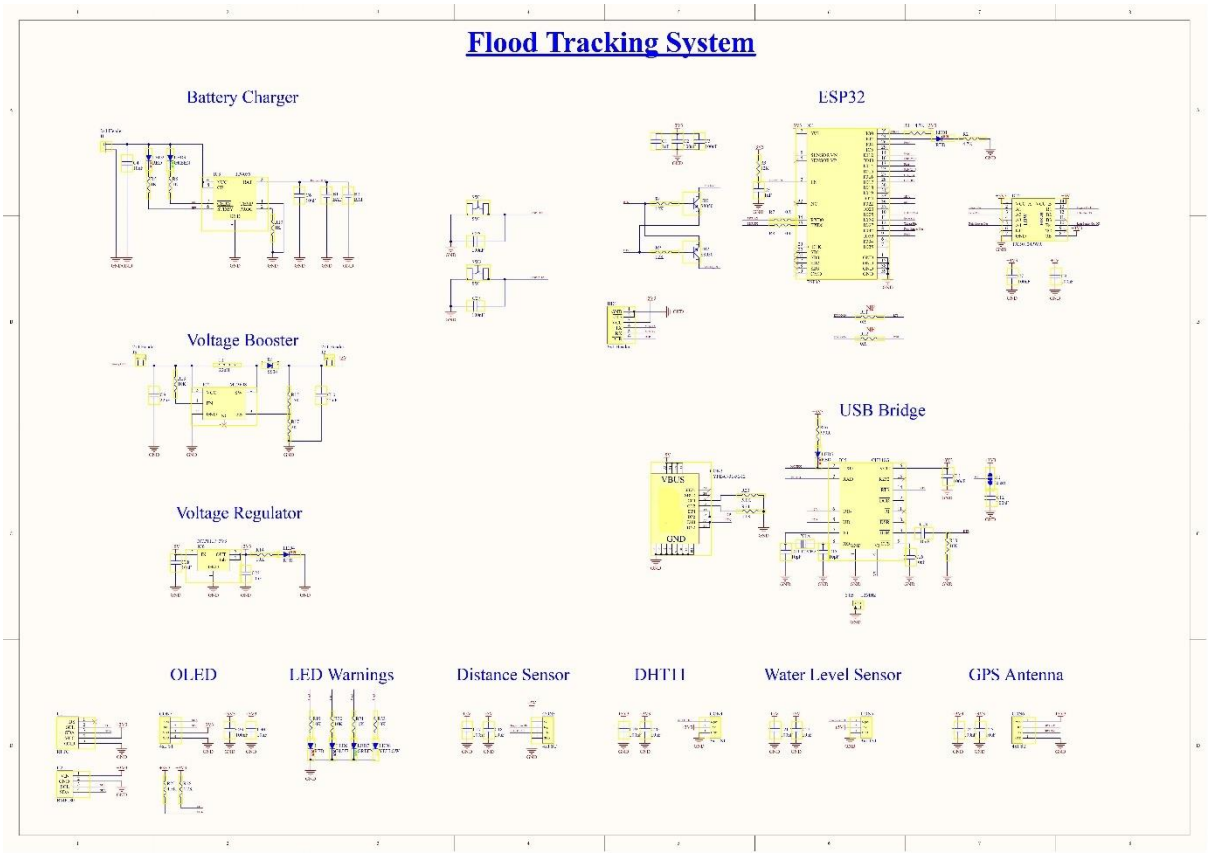


Figure 20: Schematic Design of the IoT Device

Code feeding to the IoT Device

The micro-controller and all the embedded sensors and modules are programmed with the help of the Arduino IDE to read sensor data and reveal these data on the mobile application and the Web application respective IoT dashboards. These sensors identified data will be transmitted to the Firebase Database via a locally configured Wi-Fi network to ensure the data transmission is clear. The feeding of the code to the respective IoT device is done by connecting the device to the PC/Laptop and the code is transmitted via the Arduino IDE. Once the code is fed into the device and connected to the internet and the DB connection is established you could check the status on the serial monitor of the Arduino IDE. Also, apart from that the device has an OLED screen included whereas the connection to the network could also be witnessed through this.

Weather Data Previewing on the Mobile application and the Web application

These data passed on to the DB will be extracted by the mobile application and the web application and previewed on a dashboard in the respective applications user consumption.

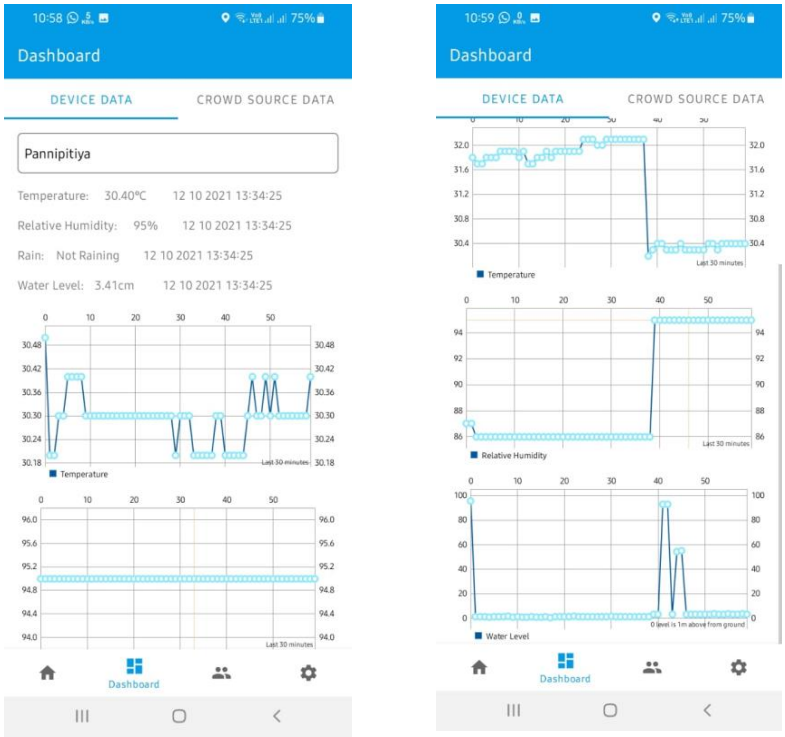


Figure 21: IoT dashboard in the Mobile Application

Figure 22: IoT Dashboard of the web application

Weather based SMS service for non-subscribed users

Reaching out the users who have not subscribed to our applications/who are unable to use our applications due to various reasons etc. Was a great challenge where we had to achieve it. But considering all possible methods and functions we were able to design a SMS weather data system whereas the user could send a request to a particular mobile number stating only the location required whereas the system will generate a reply based on the location required from user and check with Database for the latest live weather data update where an IoT device is place and transmit the same to the user.

To fulfill this request, we have used Twilio as a service provider which has the capability of purchasing a number and we could do all the configurations accordingly to that mobile number as per our system requirement.

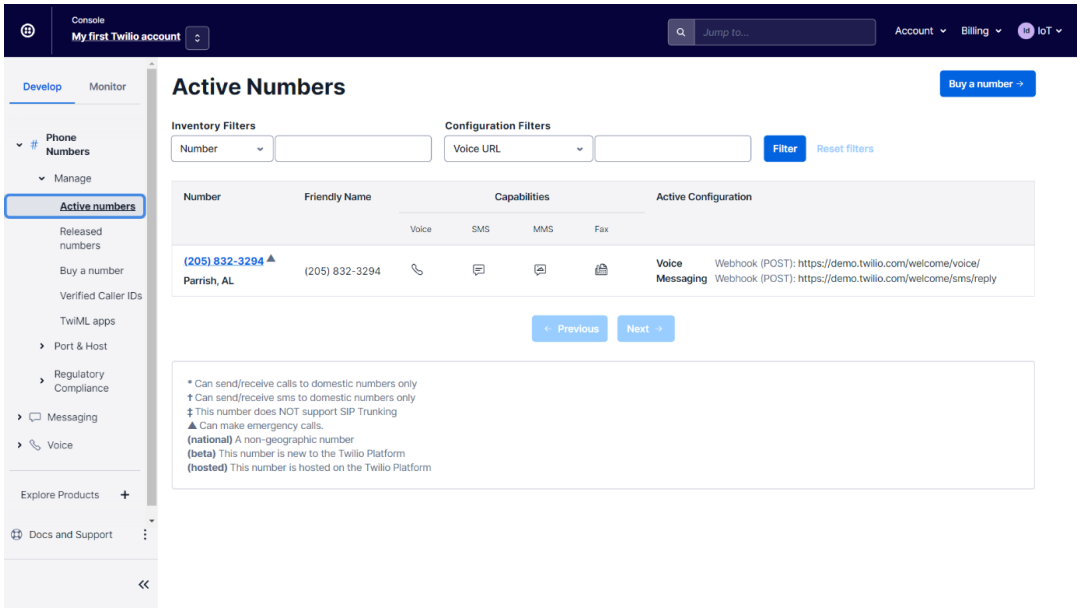


Figure 23: Purchased number in Twilio to implement the weather SMS system

IoT Device enclosure design

The designed IoT device is proposed to be covered by a plastic enclosure which will give an additional protection to the device circuit board which will also increase the functionality of the system.

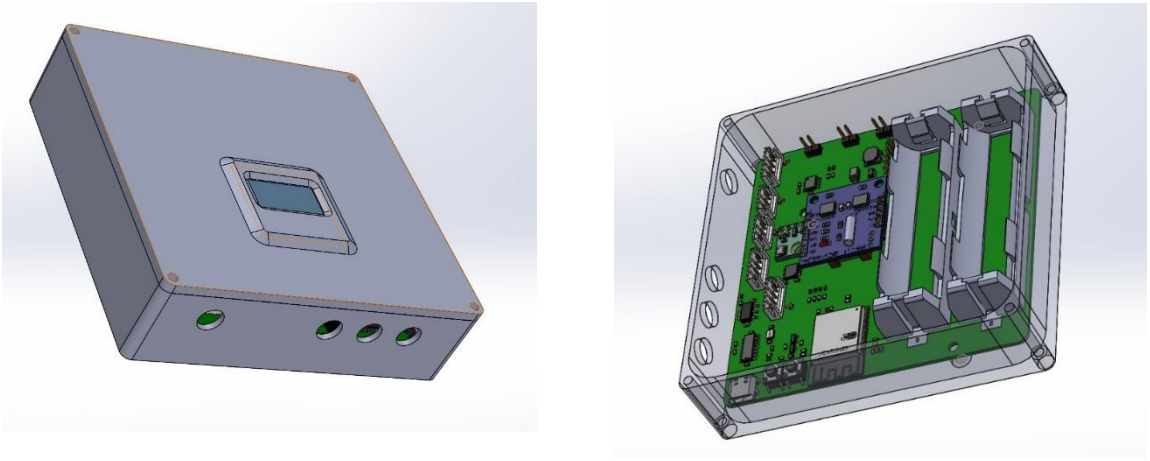


Figure 24: 3D view of the proposed enclosure design

10 Results and Discussion

10.1 Results

10.1.1 Device connection to the network

After the completion of the code writing to the Weather monitoring device which was written to detect the respective weather factors from the relevant sensors the code was successfully uploaded to the device via the Arduino IDE. All sensors need to be plugged to the device with the relevant pins in the correct slots. To feed the code to the device it needs to be plugged to the PC/Laptop with an USB connection. Once the device is plugged the connection to the network could be witnessed on the serial monitor of the IDE and the Weather monitoring device OLED too.

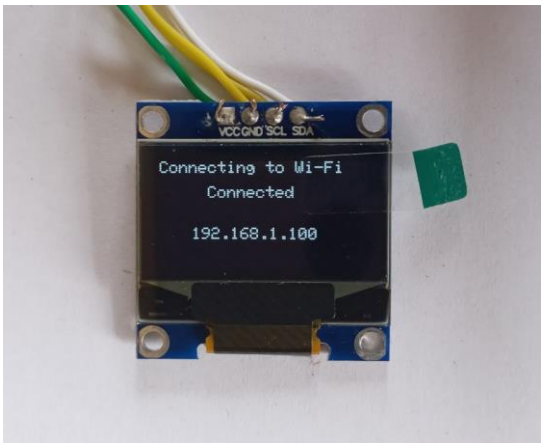


Figure 25: Network Connection preview on OLED

```
20:26:41.715 -> ..
20:26:43.712 -> Connected with IP: 192.168.1.100
20:26:43.712 ->
20:26:43.712 -> ------------------------------------
20:26:43.761 -> Sign up new user...
20:26:49.965 -> Success
20:26:49.965 -> weatherNode2
20:26:51.148 ->
20:26:51.148 ->
20:26:51.148 -> Temperature Change Detected
20:26:51.148 -> Humidity Change Detected
20:26:51.148 -> Distance Change Detected
20:26:51.148 -> Rain Change Detected
```

Figure 26: Network Connection preview on Serial Monitor

Data Preview on the OLED screen and data transmission to the Database

Once the connection to the network is successfully established the sensor detected data will be previewed on the OLED screen and will be passed onto the Database with a regular interval.

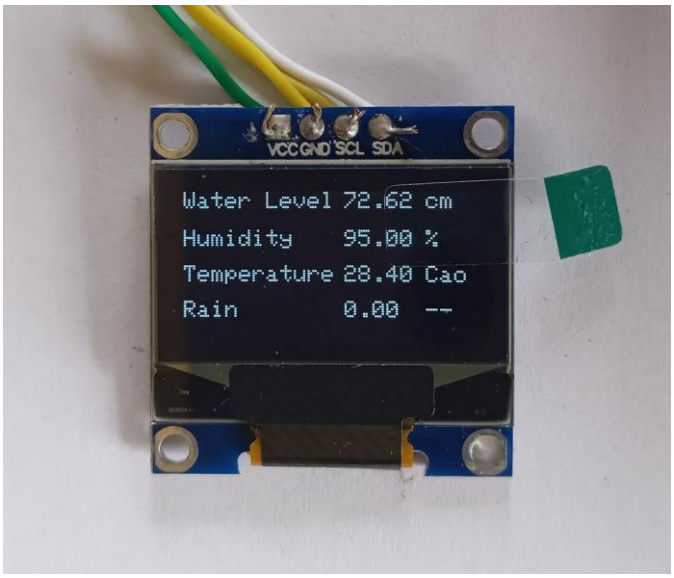


Figure 27: Sensor Data displayed on the OLED screen

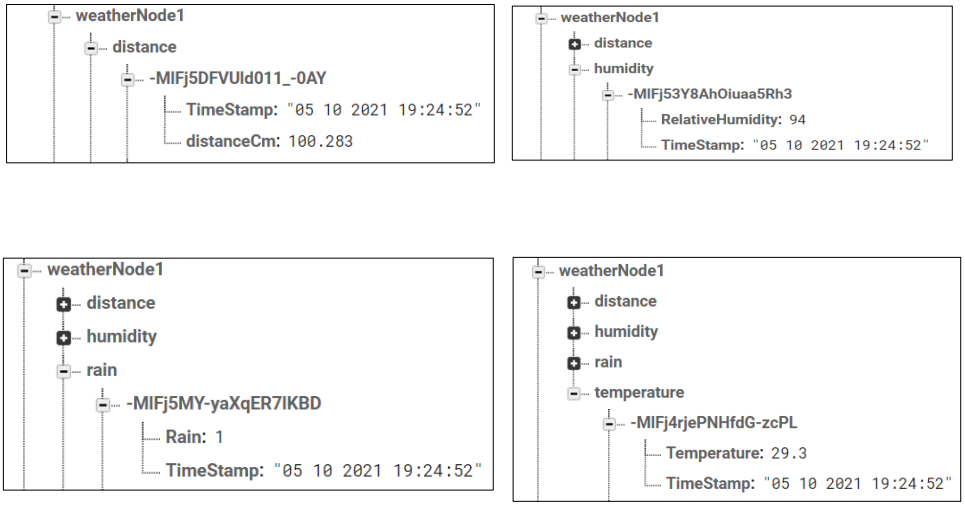


Figure 28: Sample data from the Database which were transmitted from the IOT

10.1.2 Sensor functionalities

DHT11 Temperature and Humidity Sensor

The DHT11 sensor which is used to scrutinize the temperature and the humidity of the environment of a specific location is coded to read the factors as the temperature as Celsius and the humidity as a percentage(%).

```
301 void read_DHT() {
302   delay(delayMS);
303   sensors_event_t event;
304   dht.temperature().getEvent(&event);
305   if (isnan(event.temperature)) {
306     Serial.println(F("Error temperature!"));
307   }
308   else {
309     //Serial.print(F("Temperature: "));
310     //Serial.print(event.temperature);
311     temp = event.temperature;
312     //temp = floorf(event.temperature * 100) / 100;
313     //Serial.println(F("°C"));
314 
315   }
316   dht.humidity().getEvent(&event);
317   if (isnan(event.relative_humidity)) {
318     Serial.println(F("Error humidity!"));
319   }
320   else {
321     //Serial.print(F("Humidity: "));
322     //Serial.print(event.relative_humidity);
323     humidity = event.relative_humidity;
324     //Serial.println(F("%"));
325   }
326 }
327 
```

Figure 29: DHT11 Sensor reading implementation

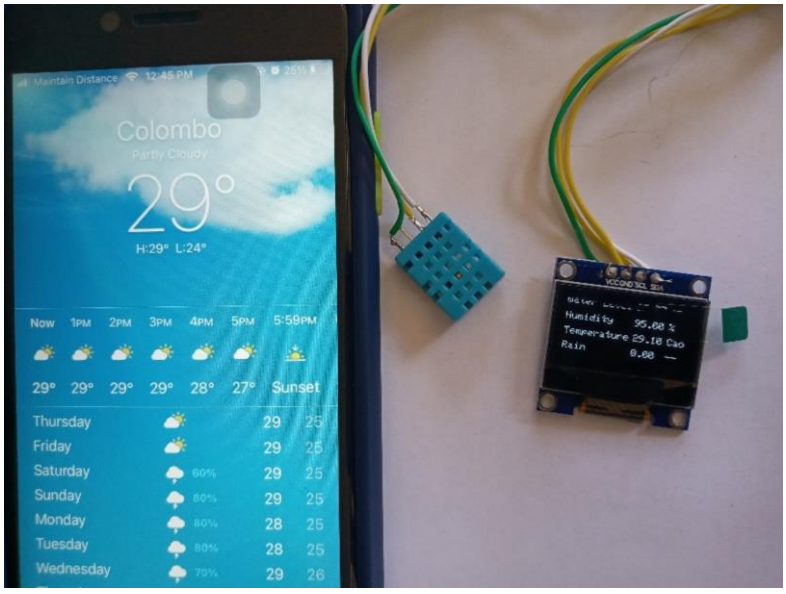


Figure 30: Sensor data reading against actual data

The code which is implemented to monitor the temperature and the humidity clearly shows that the accuracy of the sensor reading is correct against verified temperature data.

AJ-SR04T Distance Sensor Module

This distance sensor module will read the increasing of the water level in that location where the device is placed. When the distance between the sensor and the water level is decreasing which means the water level has increased.

Distance Calculation- 1 Centimeter = 0.4 Inches

Sensor distance between the water level(Increase/Decrease) $\propto$ Water level(Increase/Decrease)

```
286 void read_distance() {
287   // Clears the trigPin
288   digitalWrite(trigPin, LOW);
289   delayMicroseconds(2);
290   digitalWrite(trigPin, HIGH);
291   delayMicroseconds(10);
292   digitalWrite(trigPin, LOW);
293
294   duration = pulseIn(echoPin, HIGH);
295
296   // Calculate the distance
297   distanceCm = duration * SOUND_SPEED / 2;
298
299 }
```

Figure 31: Distance detection implementation

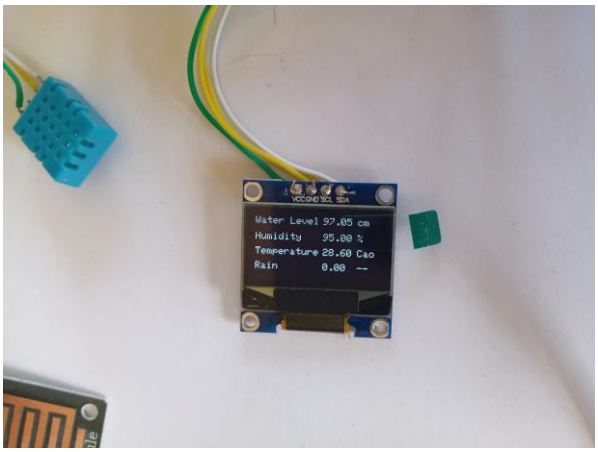


Figure 32: Distance module reading

Rain Drop Detection Sensor

The rain drop detection sensor will give a digital output as 1 or 0 as in 1 defines as when a rainfall is detected and 0 defines as when there is no rainfall.

```
277 void read_rain() {
278   if (digitalRead(Rain_sensor) == HIGH) {
279     Rain = 0.0;
280   }
281   else {
282     Rain = 1.0;
283   }
284 }
```

Figure 33: Rain Detection sensor module implementation

Figure 34: Rainfall sensor reading

10.1.3 Non-Subscribed user solution

SMS Weather Data providing

For users who are not able to access the mobile application and the web application due various reasons they are yet able to receive live weather data information, which is gathered from the weather data monitoring device via SMS. This solution is provided to the user upon user requests. Whereas the user will be able to receive weather data information via SMS only from the locations where an IoT device is placed. To fulfill this concept, we have used Twilio as our service provide to succeed this concept.

Mobile number purchased- (205) 832-3294

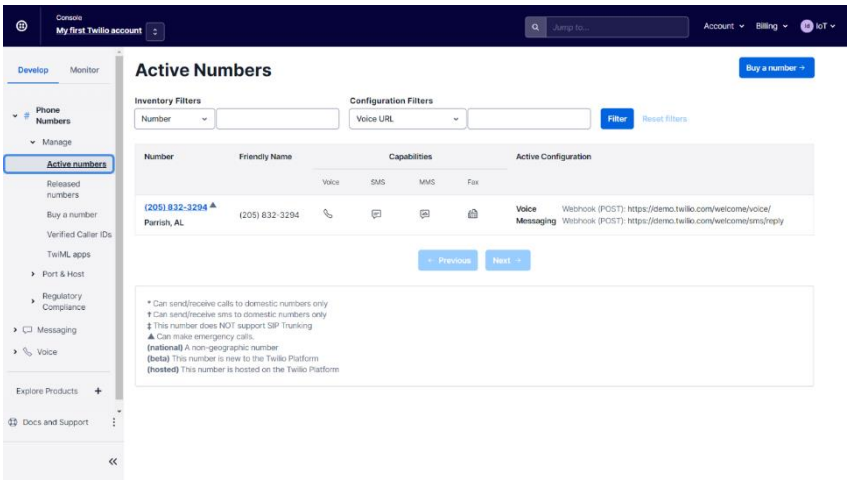


Figure 35: Twilio purchased mobile number

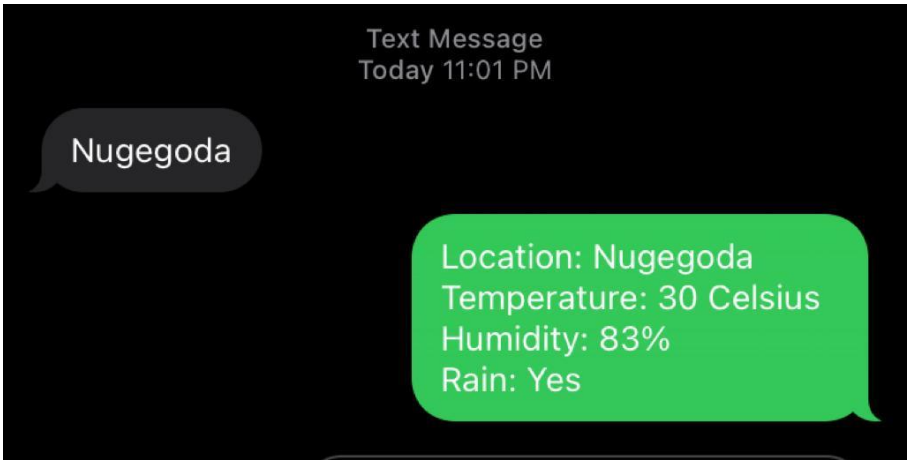


Figure 36: Sample SMS with weather information received upon user request

Data Output and Preview

The data detected by the sensors will be passed on to the Database and once the JSON file is extracted and processed to a precise format below will be preview in results.

Location	Date and Time	Distance (CM)	Humidity (%)	Rainfall (1/0)	Temperature (C)
Nugegoda	05 10 2021 19:24:52	100.283	94	1	29.3
	05 10 2021 19:25:22	100.249	94	1	29.4
	05 10 2021 19:25:52	100.266	93	1	29.4
	05 10 2021 19:26:23	100.266	93	1	29.4
	05 10 2021 19:26:55	100.283	93	1	29.4

Table 2: Data readings from the IoT device of Nugegoda

Location	Date and Time	Distance (CM)	Humidity (%)	Rainfall (1/0)	Temperature (C)
Pannipitiya	05 10 2021 19:26:55	100.283	93	1	29.4
	05 10 2021 19:28:28	100.266	93	1	29.4
	05 10 2021 19:28:59	100.266	93	1	29.4
	05 10 2021 19:29:29	100.249	93	1	29.4
	05 10 2021 19:30:00	100.249	93	1	29.4

Table 3: Data readings from the IoT device of Pannipitiya

10.2 User Interfaces

Mobile application

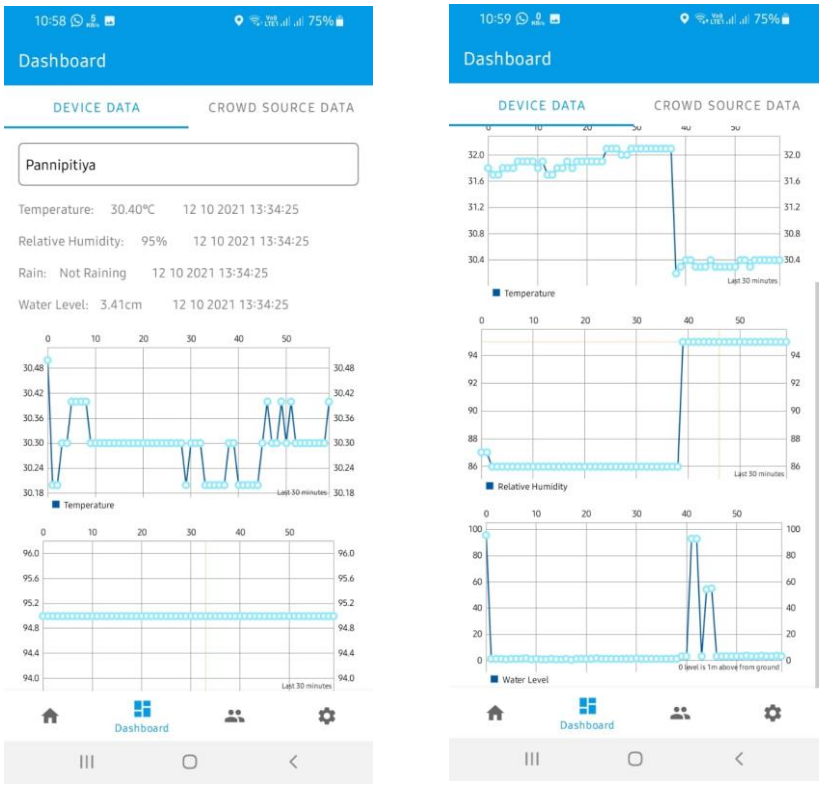


Figure 37: Data reading from the IoT device and a detailed preview on the mobile application

Web application

Figure 38: Data readings from the IoT previewed on the web application

10.3 Research findings

The main aspiration of this project is to provide an accurate early weather information regarding the arising of the water level and other factors. This proposed system isn't to be relied on as in only the main weather data factors such as temperature, Humidity, rainfall intensity, increasing water level. But by the help of these factors which are one of the main factors to cause a severe weather situation.

Choosing the most suitable microcontroller

In the current world there are numerous microcontrollers which can perform various functions in terms of IoT. We have chosen the ESP32 NodeMCU module as in this microcontroller has the functionality of connecting to the network via Wi-Fi which is also meant by there this microcontroller has and inbuilt Wi-Fi module. Currently in many other research conducted seems to be having an issue in connecting to the internet as in they have used an external Wi-Fi module. Which also reduces the performance load on that sensor which is leads to data transmission issues. To avoid all possible issues in the network connection and the data transmission to the DB we have chosen to proceed with an ESP32.

Tailor to the non-subscribed users

Reaching out to the user who does not have access to the system or application was one of our main targets as in we need to reach out to all the possible stakeholder for a better information providing. Therefore, we have chosen to reach out to such users via SMS as in this method is more feasible than approaching them through an internet connection due to various reasons such as not having an internet functioned mobile phone, out of data etc. reaching out to all the stakeholders in system has been an emerging area in the current world as in some systems

10.4 Discussion

Under this section a brief discussion about the key features of this designed IoT device and the proposed solution for users who are not able to access the system.

Precise and Feasible device structure

This designed IoT device was designed using a PCB board which will give more feasible and precise structure. Also, in terms of the durability and scalability is more efficient and higher than a normal design based on the breadboard. The relevant sensors are plugged on to the PCB board accordingly to read the relevant weather data factors. This device in in size(Width, Length, Height) is 104mm x 104mm x 20mm. Whereas a feasible size and structure was used to avoid damages occurring and easy handling in the device.

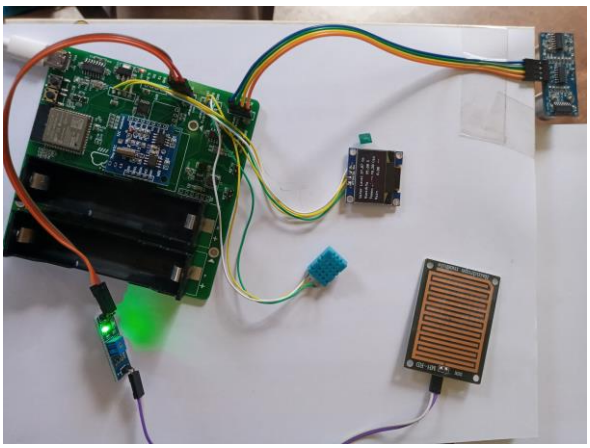


Figure 39: Structure of the IoT device

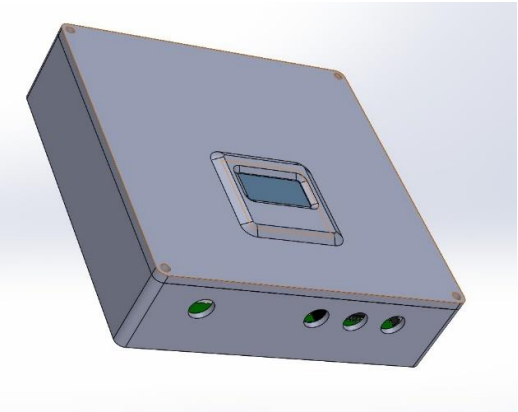


Figure 40: Designed IoT enclosure

Wi-Fi embedded microcontroller

And ESP32 has a Wi-Fi embedded module in it which has the capability of connecting to the internet to transmit data to the DB or to the relevant platform. We have used this module instead of adding an additional Wi-Fi module to device which could lead to performance issues due to the increasing size of the code.

Low cost and open source

This proposed and implemented IoT device is a low cost and open source-based platform. Low cost(Table 3) is meant by that the sensors and the components used in this assembled device could be easily found at a low cost by several vendors. These components such the sensors could be easily used as in plug and use once the code is fed to the device on the functionality of the IoT device. The Arduino device is capable to read, write & deliver the output to a certain platform.

Weather information providing SMS methodology

User who could not access our system will not be able to get the relevant weather data information. Due to this reason, we have provided a solution for them whereas they could send a SMS with the location they would like to have the weather updated and the system will return the weather data gathered from the IoT device placed in that specific location. This solution was implemented to ensure that every stakeholder could benefit from this system and could be aware of the weather information accordingly. There might be many reasons where a user isn't able to access to our system such as lack of hardware facilities, software not supporting etc. Due to this reason since an SMS is a basic functionality in every mobile any user could benefit from this system without any issues.

10.5 Summary of student contribution

Name	Component	Task
Mohamed M. F.	Desinging and developing an IoT weather monitoring system. Development of SMS weather data providing system	Extensive Study on IoT device designing & implementation. Implementation of a IoT based weather monitoring device which includes a Wi-Fi module for data transmission. Integration between the IoT device and database for the other system functionalities. Previewing the IoT gathered data on the mobile application in a detailed manner. Develop a method for users to receive weather data information via SMS.

11 BUDGET JUSTIFICATION

Component	Quantity	Price
ESP32 Microcontroller	1	LKR 1,550.00
DHT11 Temperature and Humidity Sensor	1	LKR 325.00
Rain Drop Sensor	1	LKR 200.00
HCSR04 Ultrasonic Sensor	1	LKR 250.00
RTC Module	1	LKR 160.00
Total		**LKR 2,485.00**

Table 4: Budget

12 CONCLUSION

Weather situations are one of the key factors in the day-to-day human lives. Whereas for agriculture, education, development activities etc. are some of the main areas where the weather conditions impact directly. Due to these reasons, having a proper and accurate weather change information has a valuable responsibility in enlightening the human lives.

Even though with the emerging technology in the world scrutinizing weather condition through satellites and high technology equipment's, still there are hurdles in monitoring and providing accurate weather information to a miniature area.

In this designed system we have implemented an IoT devices which has a connection with internet in terms of live data transmission and sensors embedded to the IoT device to detect weather data and will be previewed on the mobile application and web application dashboard respectively. These data could be used by various industries as in there is a direct impact of the weather situation. These industries are agriculture, traffic, logistics, development, and other day to day human activities etc.

These lively gathered data will be validated and verified with the help of the other models in this system such as using the ML, AI, and the crowdsourcing technology. Therefore, the data which is presented to the stakeholders of this system are well validated and verified data.

For the users who are unable to access the weather data via our mobile application and web application they could request weather data location wise via SMS and the relevant data of that location will be delivered to the users via the same mode. This methodology was implemented to this system as in our main aim was to reach every stakeholder of the system considering all the possible hurdles the users will face too.

As further improvements with regard to this designed Iot device it could be embed with an CMOS Camera Module which could be used for image processing where the gathered data will be verified clearly. Also, this device could be embedded more with other sensor modules such as an Anemometer, light detection sensor etc. to improve

the productivity of the device. This device could also be incorporated with a GSM module which will also benefit in terms network connection where the device will not need to connect to an external network to establish the DB connection. Since the ESP32 contains of a Bluetooth facility also this could be used to create a mesh network with the other weather monitoring IoT devices to avoid data transmission disruption.

With regard to the SMS based weather data providing methodology this could be improved by having an automated weather information providing method to user. This could be setup as the user could enroll to our service and they will receive weather data updates in a regular interval inevitably.

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