VIVEKANAND EDUCATION SOCIETY'S INSTITUTE OF TECHNOLOGY
Department of Computer Engineering

Project Report on

Identification , Analysis and Prediction of Urban Waterlogged areas

In partial fulfillment of the Fourth Year, Bachelor of Engineering (B.E.) Degree in Computer Engineering at the University of Mumbai Academic Year 2017-2018

Submitted by
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Project Mentor
Dr. (Mrs.) Gresha S. Bhatia

(2017-18)

VIVEKANAND EDUCATION SOCIETY'S
INSTITUTE OF TECHNOLOGY
Department of Computer Engineering

Certificate

This is to certify that ***Abhijeet Bhattacharya , Shripad Laddha , Nitin Pandey , Neeraj Premani*** of Fourth Year Computer Engineering studying under the University of Mumbai have satisfactorily completed the project on "***Identification , Analysis and Prediction of Urban Waterlogged areas***" as a part of their coursework of PROJECT-II for Semester-VIII under the guidance of their mentor ***Dr. (Mrs.) Gresha S. Bhatia*** in the year 2017-2018 .

This project report entitled ***Identification , Analysis and Prediction of Urban Waterlogged areas*** by ***Abhijeet Bhattacharya, Shripad Laddha, Nitin Pandey, Neeraj Premani*** is approved for the degree of ***Computer Engineering***.

Programme Outcomes	Grade
PO1,PO2,PO3,PO4,PO5,PO6,PO7, PO8, PO9, PO10, PO11, PO12 PSO1, PSO2	

Date:

Project Guide: Dr. (Mrs.) Gresha S. Bhatia

Project Report Approval
For
B. E (Computer Engineering)

This project report entitled ***Identification , Analysis and Prediction of Urban Waterlogged areas*** by ***Abhijeet Bhattacharya , Shripad Laddha , Nitin Pandey , Neeraj Premani*** is approved for the degree of ***Computer Engineering***.

Internal Examiner

External Examiner

Head of the Department

Principal

Date:
Place:

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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(Signature)	(Signature)
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(Abhijeet Bhattacharya D17B 09)	(Shripad Laddha D17B 38)
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(Signature)	(Signature)
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(Nitin Pandey D17B 52)	(Neeraj Premani D17B 56)

Date:

Certificate of Industrial Project

MUNICIPAL CORPORATION OF GREATER MUMBAI

AC M/W/ 09 / 1146 /AE(M) dt. 27.9.17

INDUSTRY PROJECT

The office of the,
Asstt. Commissioner (M/West Ward),
'M' Ward Office Building, 1st Floor,
Sharadbhau Acharya Marg,
Chembur (East), Mumbai – 400 071.

This is to certify that the students namely **shri. Neeraj Premani, shri Nitin Pandey, shri Shripad Laddha & shri Abhijeet Bhattacharya**, BE Final Year, Computer Engineering, VESIT are developing a project titled " Identification, Analysis and Prediction of urban -waterlogging areas" under the guidance of Dr.(Mrs.) Gresha S. Bhatia, Deputy HOD,VESIT and Mr.Shrikant Rade, Sub Engineer(Maint.) & Mr. Bhaskar Kasgikar, Asstt. Engineer (Maint.) of MCGM. The said is scheduled to be completed before June 2018.

This project entails providing important information and data records. The data provided from us has to be utilized for academic purposes only.

Mr. Shrikant Rade
Sub Engineer (Maint.)
MCGM

Mr. Bhaskar Kasgikar
Asstt. Engineer (Maint.)
MCGM

MUNICIPAL CORPORATION OF GREATER MUMBAI

AC M/W/ 01 / 1005 / Maint. Date:- 27.03.2018

Project Completion Certificate

Subject: Successful completion of the project "Identification, Analysis and Prediction of Urban Waterlogged Areas" under the guidance of Dr. Mrs. Gresha S Bhatia and Mr. Shrikant Rade from MCGM.

This is to certify that final year students of Computer Engineering Department, VESIT : Mr. Abhijeet Bhattacharya, Mr. Shripad Laddha, Mr. Nitin Pandey and Mr. Neeraj Premani under the guidance of Dr. Mrs. Gresha S Bhatia and Mr. Shrikant Rade have successfully completed the project titled **"Identification, Analysis and Prediction of Urban Waterlogged Areas"** in M/West ward of MCGM, with all the required documents and reports, during the period from 20th August 2017 to 20th March 2018.

1. It has been observed that the project is of social importance and fulfills the need of the hour.

2. This project if given a chance to be implemented by the organization would enable the detection of water logging on a near real time basis.

3. The seamless integration of the project into the existing system would aid in an efficient and effective mitigation process.

4. This project would further ensure the smooth conduction of the human resources through the notification tab designed especially for the management of the organization.

5. Reports generated by the project can be used as a input for big data analytics and improvise the entire water logging system handling machinery.

The efforts taken by the students are highly commendable and they have left no stone unturned to complete the project on time and as per the requirements furnished to them

This project with MCGM entailed dealing with important and sensitive information, records and such other matters of the MCGM. The project would be utilized for academic purpose only.

27/03/18

Asst. Engineer (Maintenance) M/West

Date :27.03.2018.

Place :Chembur (E).

ACKNOWLEDGEMENT

We are thankful to our college Vivekanand Education Society's Institute of Technology for considering our project and extending help at all stages needed during our work of collecting information regarding the project.

It gives us immense pleasure to express our deep and sincere gratitude to Assistant Professor **Dr. (Mrs.) Gresha S. Bhatia** (Project Guide) for her kind help and valuable advice during the development of project synopsis and for her guidance and suggestions.

We are deeply indebted to Head of the Computer Department **Dr.(Mrs.) Nupur Giri** and our Principal **Dr. (Mrs.) J.M. Nair ,** for giving us this valuable opportunity to do this project.

We would like to thank **Mr. Shrikant Rade** sir (BMC sub. Engineer) for their help and giving us this valuable opportunity to do this project for the BMC.

We express our hearty thanks to them for their assistance without which it would have been difficult in finishing this project synopsis and project review successfully.

We convey our deep sense of gratitude to all teaching and non-teaching staff for their constant encouragement, support and selfless help throughout the project work. It is great pleasure to acknowledge the help and suggestion, which we received from the Department of Computer Engineering.

We wish to express our profound thanks to all those who helped us in gathering information about the project. Our families too have provided moral support and encouragement at several times.

Computer Engineering Department
COURSE OUTCOMES FOR B.E PROJECT

Learners will be to,

Course Outcome	Description of the Course Outcome
CO 1	Able to apply the relevant engineering concepts, knowledge and skills towards the project.
CO2	Able to identify, formulate and interpret the various relevant research papers and to determine the problem.
CO 3	Able to apply the engineering concepts towards designing solution for the problem.
CO 4	Able to interpret the data and datasets to be utilized.
CO 5	Able to create, select and apply appropriate technologies, techniques, resources and tools for the project.
CO 6	Able to apply ethical, professional policies and principles towards societal, environmental, safety and cultural benefit.
CO 7	Able to function effectively as an individual, and as a member of a team, allocating roles with clear lines of responsibility and accountability.
CO 8	Able to write effective reports, design documents and make effective presentations.
CO 9	Able to apply engineering and management principles to the project as a team member.
CO 10	Able to apply the project domain knowledge to sharpen one's competency.
CO 11	Able to develop professional, presentational, balanced and structured approach towards project development.
CO 12	Able to adopt skills, languages, environment and platforms for creating innovative solutions for the project.

Abstract

Waterlogging is one of the major misfortune faced by human beings, It mainly occurs in rainy season due to excess of rainfall in lowline areas or closed areas. Normal approaches are not enough to prevent it and also we lag any real time system to identify and cure the waterlogging. In the last rainy seasons there were increment in the occasions of the waterlogging in the mumbai region which had severe effects on the working of the region leading to jamming of highways and various sanitary problems.

The proposed project is based on the real time tracking of the waterlogged areas, which will not only keep the authorities updated about the current and future status of the waterlogging but also native people can also contribute in order to report the waterlogging in the local area via FB Chat Bot.

In the proposed system in order to satisfy the real time identification of the waterlogging; ultrasonic sensors have be used, which will be installed at the particular height on street lights which will give the current data to server for the identification and analysis. In order to be ready for the waterlogging, prediction module is there which will give the short term, medium term and high term prediction of the particular area. There will be final report which will give the visualization of the sensors data, FB reported areas in order to understand the results easily.

In order to notify the officials about the current waterlogging message notification will be provided to the assigned officer of that area. The Notification module will also help the officers to give the direction to its subordinate.

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Chapter 1
Introduction

1.1 Introduction to the project

Waterlogging means that accumulation of excess water in particular area due to excess rainfall in short period of time.When there is more inflow of the water than the outflow , water starts getting accumulating in the low areas or the closed areas which results in the waterlogging.Waterlogging mainly happens in the rainy seasons in India it starts from June and ends in the october.There are some other factors which also contribute to the waterlogging which are height of the area from mean sea level , because if the height of the particular area is low even the lesser rainfall will results into the waterlogging.Other factors include High tide , specially if area is closer to the sea like mumbai , High tide major role for the coastline areas because the drainage outlets are the sea if there is high tide drainage of the area gets blocked which results into the lower outflow the rainwater or sometime it increases the inflow of the water in the area.The used area for this project is mumbai city specially a chembur region.Currently for the cure of the waterlogging there is no advanced systems which can identify it in real time and update the authorities about it.The current issues of the waterlogging gets resolved by the phone calls to the authority and other inefficient measures.The proposed system aims to resolve the above problems by providing real time tracking of the waterlogged areas and provide short term ,medium term and long term prediction of the waterlogging in the particular region[1].

1.2 Motivation for the project

Due the waterlogging there are major consequences in the city or the region like damages to human life(due to accidents) , government properties , seasonal diseases and sanitary problems.In the previous rainy seasons there were two measure occasions of the waterlogging one near the 29th august and other one on the 19th september which has lead to bad effects on the people , their properties and disturbed the environment of the city. The main motivation behind the project is build a working prototype to give real time identification of waterlogging.In India there is central water commision but it has limited reach , so there was strong need for the real time identification system [2] .In the USA there is Stormwater Management Model which is basically based on the water inflow and outflow in particular area [3].

1.3 Problem Definition

Currently active system to resolve waterlogging is very inefficient and not very effective. Native people report the waterlogging via phone calling to the authority. Then depending upon on the availability of the motors and working staff they take required actions. The proposed project aim to provide real time identification of the waterlogging along with several great features like making prediction for different terms, Notifying the officials with respect to current status of waterlogging. There are also visual reports so that end users will understand it easily.

1.4 Relevance of the project

Since we lag the real time Identification of the waterlogging it is very important aspect of the proposed system and it will be appreciable if the system will be able to notify the information beforehand, about the coming waterlogging. This prediction will help the authorities to monitor the waterlogging. The result would alert the BMC officials in advance that would enable them to take preventive actions, thus reducing the devastating effects of waterlogging.

Identifying Waterlogging is essential in the initial phase itself. Our system helps to identify waterlogging and accordingly help the BMC officials to take necessary actions to solve the problem of waterlogging. Apart from the identification part it also helps to predict the waterlogging in a certain area.

1.5 Methodology employed for development

Sensor nodes will be installed at multiple locations in a star topology with router at the center of each star network. These routers will be connected to a gateway which is connected to the internet.

- For the backend Google Cloud Platform has been used , which provides services like Google Iot core , Google Ml Engine which are most essential in project.[4]
- Identification Module identifies waterlogging areas using the sensor data and sends notification to respective officials.
- Analysis Module measures the severity by calculating a severity score based on parameters like water level,precipitation amount,tide status.
- Prediction Module predicts waterlogging areas in terms of short,medium and long term.

Chapter 2
Literature Survey

A literature survey or a literature review is the section which shows the various analyses and research made in the field of your interest and the results already published, taking into account the various parameters of the project and the extent of the project. It is the most important part of report as it gives you a direction in the area of your research. It helps you set a goal for your analysis - thus giving you your problem statement.

2.1 Literature survey and its various sources

The main source of the literature survey includes the Research papers , newspaper articles and interaction with the domain experts.For the proper research we have referred 8 IEEE papers the details of the papers have been provided below.[5]

Research Papers :

We studied the following Ten papers which are summarized as below:

1. **Title**: Prachatos Mitra,Ronit Ray,Retabrata Chatterjee, "Flood forecasting using Internet of things and Artificial Neural Networks",IEEE,10.1109/IEMCON.2016.7746363 [6]

   Abstract: In this paper,IoT and machine learning based embedded system is proposed to predict the probability of floods in a river basin. A ZigBee based WSN is used to collect data and GPRS module is used to send data over internet.

   Inference:

   Collects data from Sensor.Using AI to predict flood prone areas.Used WSN based on zigbee specification using mesh topology.Used ANN composed to 3 layers to make flood forecasting

2. **Title**: A. D. Choudhury,A. Agrawal,P. Sinha, "A Methodology for GPS-based waterlogging prediction and smart route generation", IEEE, 10.1109/ISDA.2012.6416550. [7]

   Abstract: This paper is based on the theory that water accumulates in low-lying areas and that a route containing more and bigger basins is likely to behave worse in rainy day. To measure the error rate, the confidence score for multiple routes are compared with judgements provided by commuters.

   Inference:

   Predicting water logged prone areas on multiple routes.The paper proposes Algorithm for location detection and algorithm for score calculation

3. **Title**: Fazlina Ahmat Ruslan,Abd Manan Samad,Zainazlan Md Zain, “Flood prediction using NARX neural network and EKF prediction technique”, IEEE, 10.1109/ICSEngT.2013.6650171. [8]

Abstract: Since prediction using conventional neural network does not provide reliable results due to its inability to reflect dynamic characteristic of water level, NARX NN is proposed as the identification model.Results showed that NARX model performed better than EKF prediction technique.

Inference:

NARX NN used as identification model :Dynamic nature of Water level.Better than EKF (static estimator).Accurate prediction than static neural network (Backpropagation).EKF can be integrated with NARX

4. **Title**: Fazlina Ahmat Ruslan,Abd Manan Samad,Zainazlan Md Zain, “Modelling Flood Prediction Using Radial Basis Function Neural Network (RBFNN)”, IEEE, 10.1109/ICCSCE.2013.6720031. [9]

Abstract: In this paper, artificial neural network capable of modeling nonlinear and complex systems is presented. A Radial Basis Function Neural Network (RBFNN) was developed for flood water level prediction at Kelang river located at Petaling Bridge. Results reveal that RBFNN can be considered as a suitable technique for predicting flood water level.

Inference:

Alternative approach for accurate flood prediction: an artificial neural network which is capable of modeling nonlinear and complex systems.Better than traditional system : Model nonlinear and complex systems

5. **Title**: Xianfu Zhao,Jin Qian,Fengchang Xue, “GIS-Based Spatial and Temporal Analysis of Regional Water-logging Confluence”, IEEE, 10.1109/CSO.2011.141. [10]

Abstract: This paper discuss the method of calculating the waterlogging of the surface in the region.Combined using the spatial analysis in GIS with calculating the "Isochrones" in the confluence of regional water-logging, to describe the distribution of the confluence in space and the strength of the confluence in time

Inference:

Inputs:GIS spatial analysis,Water inflow,Water outflow.Output:Calculation of confluence,space and time maps of spatial and temporal distribution of the waterlogging confluence.Only in selected area.

No consideration of other factors like pipe bursting

6. **Title**: Victor Seal, Arnab Raha, Shovan Maity, Souvik Kr Mitra, Amitava Mukherjee, Mrinal Kanti Naskar, "A simple flood forecasting scheme using wireless sensor network", arxiv, 10.5121/ijasuc.2012.5. [11]

Abstract: This paper presents a forecasting model designed using WSNs (Wireless Sensor Networks) to predict flood in rivers using simple and fast calculations to provide real-time results and save the lives of people who may be affected by the flood.

Inference: WSN to predict flood.Near real time. Prediction model is independent of the number of parameters. When the water level rises, we represent it using a polynomial whose nature is used to determine if the water level may exceed the flood line in the near future. It's near real time and cost effective

7. **Title** : Md. SMd. Shareful Hassan, Syed Mahmud-ul-islam - Detection of Water-logging Areas Based on Passive Remote Sensing Data in Jessore District of Khulna Division, Bangladesh - published at: "International Journal of Scientific and Research Publications (IJSRP), Volume 4, Issue 12, December 2014 Edition". [12]

Abstract: In this research paper, Jessore district of Khulna division was selected as the study area to detect water-logging. In this analysis, a multi-regression analysis was performed using Upazila wise water-logged as independent variable and Upazila wise damaged agricultural lands as dependent variable.

Inference:

Three classified images, a union operation was used in raster calculator in ArcGIS platform. Normalized difference vegetation index (NDVI) and normalized difference water index (NDWI)for information of water and agriculture.

8. **Title**: Dong Qianjin,Yu Qian, "Application of piecewise linear model to waterlogging level forecasting", IEEE, 10.1109/APPED.2010.37. [13]

Abstract: In this paper, according to the characteristics of flood control and drainage in Luohu District of Shenzhen city, a water logging level forecasting model corresponding to the rainfall is proposed with piecewise linear model.

Inference:

Waterlogging level forecasting model corresponding to the rainfall is proposed with piecewise linear model forecasting model of the water level.

Sr no	TITLE	GIST	PARAMETERS		ADVANTAGES	DISADVANTAGES
			INPUT	OUTPUT		
1.	Flood forecasting using Internet of things and Artificial Neural Networks [6]	● Collects data from Sensor ● Using AI to predict flood prone areas	● Sensor Data	● Prediction	● Efficient architecture	Network Setup
2.	A Methodology For GPS-based waterlogging Prediction and smart Route Generation. [7]	● Predicting water logged prone areas on multiple routes ● Algorithm for location detection ● Algorithm for score calculation	● Static information ● GPS altitude data ● Google elevation API services	● Confidence score for various routes ● Prediction of low valleys	● Algorithms for the score calculation	● False alarms ● NO ground truth
3.	Flood prediction using NARX neural network and EKF prediction technique. [8]	● NARX NN used as identification model :Dynamic nature of Water level ● Better than EKF (static estimator)	● Experimental data for the autoregressive variables	● Experimental data for the autoregressive variables at a later time, t	● Accurate prediction than static neural network (Backpropagation)	● Lack of input parameter

4.	Modelling Flood Prediction Using Radial Basis Function Neural Network (RBFNN). [9]	• Alternative approach for accurate flood prediction: an artificial neural network which is capable of modeling nonlinear and complex systems	• Water level data	• Detection of flood prone areas	• Better than traditional system : Model nonlinear and complex systems.	• Lack of input parameters
5.	GIS-Based Spatial and Temporal Analysis of Regional Water-logging Confluence. [10]	• Regional confluence of waterlogging	• GIS spatial analysis • Water inflow • Water outflow	• Calculation of confluence • space and time maps of spatial and temporal distribution of the waterlogging confluence.	• Consideration of water inflow and outflow	• Only in selected area • No consideration of other factors like pipe burstin g
6.	A Simple flood forecasting scheme using wireless sensor network. [11]	• WSN to predict flood • Near real time • prediction model is independent of the number of parameters • When the water level rises, we represent it using a polynomial whose nature is used to determine if the water level may exceed the flood line in the near future	• Linear regression	• Prediction of flood	• Near real time • Cost effective	• Low resource utilization
7.	Simulation of Rainstorm Waterlogging Based on SWMM and Visualization Module Research. [14]	• Points of EPA SWMM model • Application of SWMM in study and are a visual interface display	• SWMM model • Three solving methods	• River drainage simulation • Drainage pipe network system verification and management	• SWMM model can be used for single event or long term	• SWM M is a fully develop ed model
8.	Prediction of Water Logging Using Analytical Solutions—A Case Study of	• Seepage from canals • Area prone to waterlogging mapped using GIS	• Details of inner lining of canals • GIS for spatial data	• Area prone to waterlogging	• Consideration of seepage problem • Solution	• No seepage proble m in metrop

	Kalisindh Chambal River Linking Canal. [15]		management and analysis		to 3D field	olitan like mumba i • Inaccur ate for dynami c environ ment

Table 2.1 : Survey Table

2.2 Newspaper Articles

1. NDTV:Mumbai: Heavy Rains Cause Traffic Snarls, Local Trains Disrupted(Date: 11th July 2014)

NDTV Business Hindi Movies Cricket Lifestyle Health Food Tech Auto Apps Trains Art Weddings

NDTV

SECTIONS HOME | MUMBAI

Mumbai: Heavy Rains Cause Traffic Snarls, Local Trains Disrupted

Mumbai | Press Trust of India | Updated: July 11, 2014 13:46 IST

TRENDING

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EMAIL PRINT 1 COMMENTS

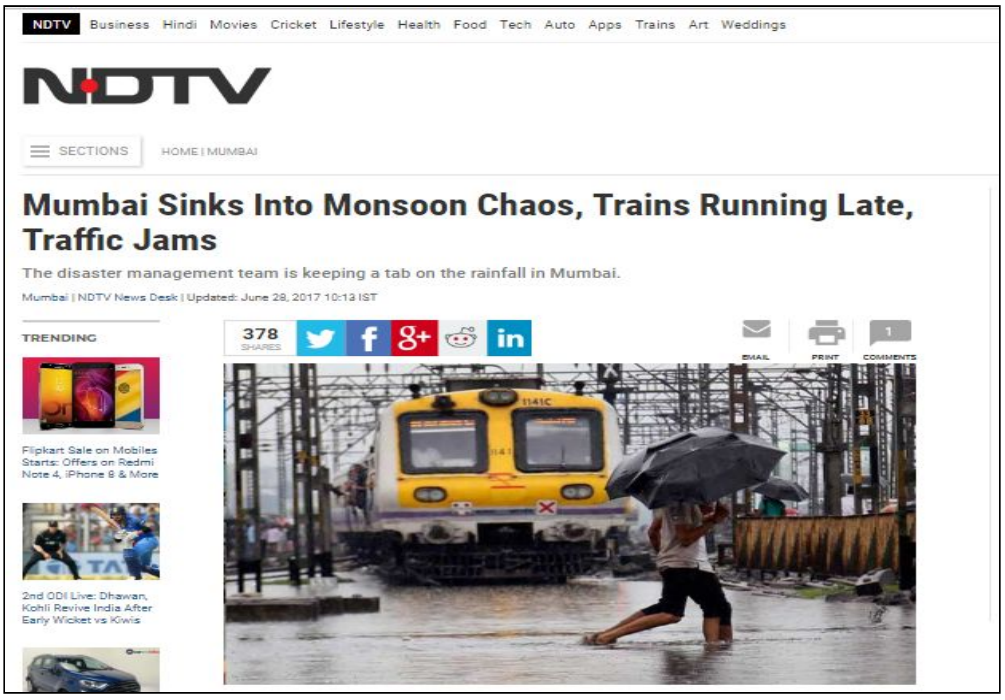
File photo of waterlogging in Mumbai during monsoon rains

MUMBAI: Water logging due to heavy rains that continued to lash the city for a second consecutive day caused major traffic snarls and also disrupted the suburban train services.

"There is water logging in low lying areas like Dadar, Parel, Sion, Kurla, Ghatkopar and the Western Express Highway which has caused severe disruptions in vehicular traffic along the stretches. The MCGM is trying to pump out water from these areas so that the situation can be normalised," a senior official of the Municipal Corporation of Greater Mumbai (MCGM) told PTI.

Source:https://www.ndtv.com/mumbai-news/mumbai-heavy-rains-cause-traffic-snarls-local-trains-disrupted-586972

2. NDTV:Mumbai Sinks Into Monsoon Chaos, Trains Running Late, Traffic Jams(Date: 28th June 2017)



Source:https://www.ndtv.com/mumbai-news/mumbai-sinks-into-monsoon-chaos-trains-running-late-traffic-jams-1717784

3. Hindustan Times: Heavy rains bring Mumbai to a halt, people stuck in massive traffic snarls(Date: 30th August 2017)

Waterlogging near Mulund station due to heavy rain in Mumbai on August 29.(Praful Gangurde/ HT Photo)

Source:http://www.hindustantimes.com/mumbai-news/traffic-nightmare-in-mumbai-as-city-reels-due-to-heavy-rains-flights-train-services-affected/story-gW23L6Ve9wZvNWzAWjghzN.html

Interaction with Domain expert :

On interaction with Mr. Shrikant Rade (Sub Maint. Engg) we identified that the most important problem they face is identification of waterlogged areas. BMC officials still rely heavily on phone calls and SMS to identify waterlogged areas which is inefficient and time consuming. Our system consists of identification,analysis and prediction module with more emphasis on identification using Wireless Sensor Network (WSN) based on star topology.

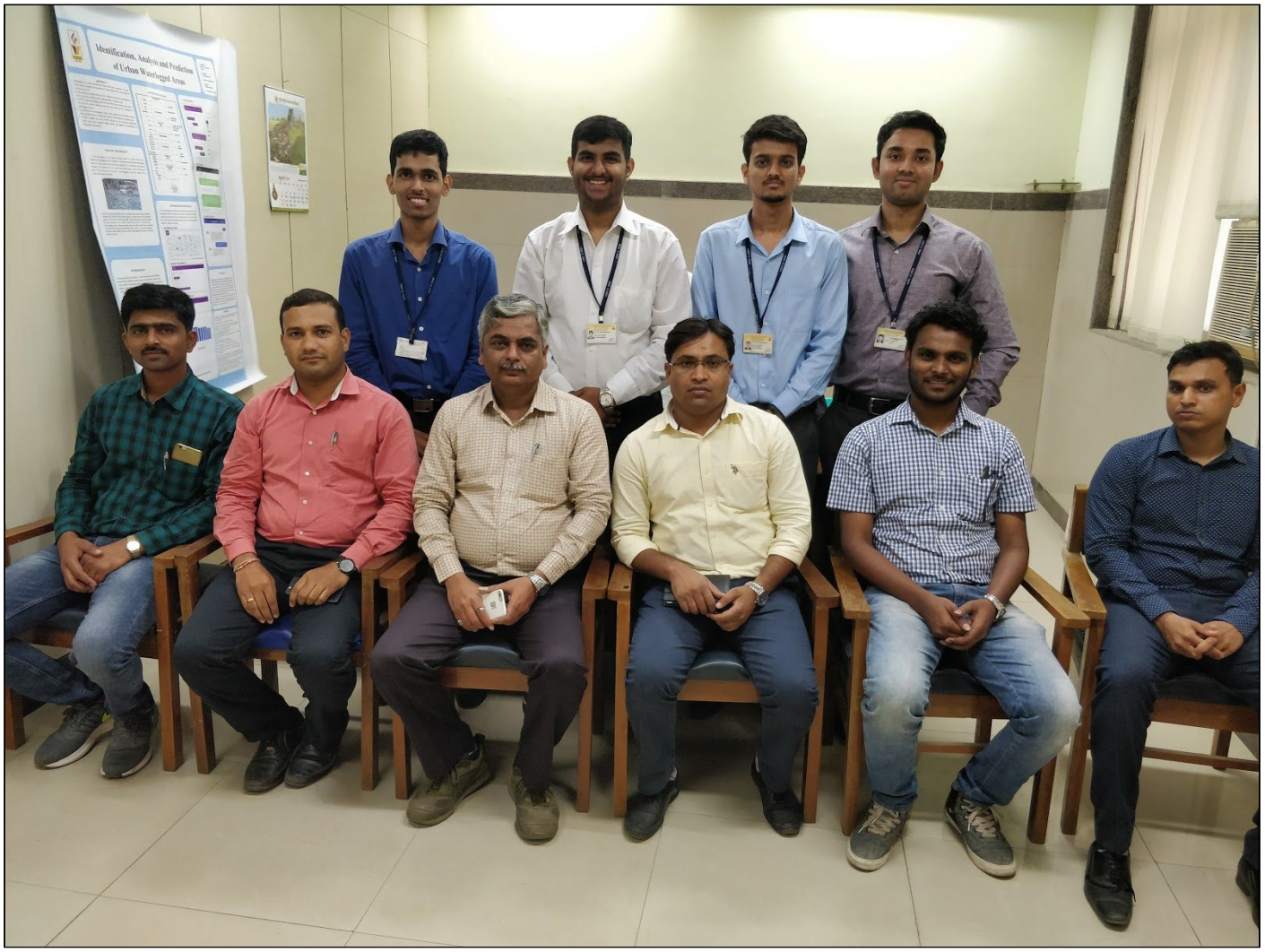


Figure 1 : Interaction with BMC members

2.3 Patent Search

1. Title: "Wireless sensor network with ambient energy harvesting",Abdul, W.A.Masuri, O.M, M.U.Z.A.S.Wan, H.W.K.https://www.google.com/patents/WO2010093234A2?cl=en2010,Google Patents. [16]

Summary:

The patent presents ways to power wireless sensor system by harvesting of ambient energy such as wind, solar or thermal energy. This methods rules out the necessity to power nodes from a central source. The sensor motes consists of various sensor, that are capable of generating data signals based on parameters measured as well as transmitters that send those signals(containing sensor measurement) to a router located in a remote location.

2. Title: "Wireless sensor network with energy efficient protocols ", Sultan , F.Zummo, S.A.Al-Absi , M.A.K.Shafi , A. https://www.google.com/patents/US85479822013,Google Patents [17]

Summary:

The patent explains the various energy efficient protocols that are used in a wireless sensor network (WSN). Such networks use an algorithm which is integrated with S-MAC protocol to reduce the energy usage in operation of node and associated sensors. The routing protocol is based upon cluster head rotation.

Chapter 3
Requirement of Proposed System

Our proposed system collects data in application server from sensors via internet in a regular interval of 5 min. Once data is received the identification module identifies the water level and details about respective authorities for all areas. This data is transferred to the Analysis module,wherein score is calculated based on parameters like current water level,current precipitation amount,high tides and drainage status. This score is used to measure severity of waterlogging.

Requirement is a singular documented physical and functional need that a particular design, product or process must be able to perform. It is a statement that identifies a necessary attribute, capability, characteristic, or quality of a system for it to have value and utility to a customer, organization, internal user, or other stakeholder. A requirement specification (often imprecisely referred to as the spec, because there are different sorts of specifications) refers to an explicit set of requirements to be satisfied by a material, design, product, or service. Requirement is a basic building block of the system which are either direct or indirect i.e of two basic types of requirements

1. Functional requirement
2. Non-functional requirement

A **functional requirement** defines a function of a system or its component. A function is described as a set of inputs, the behavior, and outputs.

A **non-functional requirement** (NFR) is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviors. They are contrasted with functional requirements that define specific behavior or functions.

3.1 Functional Requirements

1. **Accuracy**

   Proposed system should have high degree of accuracy in order to avoid false positives and false negatives.

2. **Efficiency**

   Wireless Sensor Network (WSN)[18] has to be implemented in such a way so that it can continue working for a period of 3-4 months using cells.

3. **Prediction**

   Prediction should have high degree of accuracy. Prediction are done in short,medium and long term.

4. **Notification**

   Notification to respective BMC officials is done via SMS,push and web application.

5. **Identification**

   Identification module provides near real time identification of waterlogged areas by collecting data via the WSN.

6. **Analysis (Severity of flood)**

   Analysis module computes the severity of waterlogging areas based on various parameters like current precipitation amount,tide status, current water level.

3.2 Non-Functional Requirements

1. **Security**

   The main concern is to prevent the system from unauthorized access so that system data is not compromised.

2. **Availability**

   The system should be available to the authorized users 365 days 24*7.

   If the internet service gets disrupted while sending information to the server , the information can be send again for verification.

3. **Portability**

   As our proposed system is a online web portal it can be accessed from mobile browsers as well as Computer browsers by authorized users only.

4. **Maintainability**

   Maintainability with respect to web portal will include easiness to maintain the website and with respect to the sensors and routers will include correcting the defects on their cause, replace and repair the faulty ones, make future maintenance easier and maximize the efficiency,safety,reliability and useful life of the product.

5. **Response Time**

   Response time is the total amount of time it takes to respond to a request for service. That service can be anything from a memory fetch, to a disk IO, to a complex database query, or loading a full web page.

3.3 Constraints

1. Accuracy of data from IMD(Indian Meteorological Department)

   We assume the rainfall data obtained from India Meteorological Department is accurate so that our prediction module works effectively

2. Cleaning of Drainage system before rainy season

   The proper cleaning of drainage system plays a major role in determining waterlogging in an area. We presume that the drainage system i.e. sewers,manholes etc. are properly cleaned.

3. Proper working of pumps

   For the proper working of our system, we have assumed that all the pumps are in working condition.

4. The sensor provide accurate data.

   Accuracy of Identification module depends on the accuracy of sensors. RPS-41A provides high degree of accuracy.

5. Mapping of location names with officers has been done already

   Mapping of location name with officer details like officer name,contact number,email id is provided by BMC.

6. Proposed solution should consume less power

   WSN cannot be powered using electricity cables,therefore it has to be powered using cells.Since rainy season lasts for 3-4 months, our system should consume less power in order to continue working.

7. Sensors should be able to cover waterlogging prone areas

   The sensor's coverage area must be able to detect waterlogging in the area where it is fitted.

3.4 Requirements For The System

Hardware requirements are

1. Ultrasonic Sensor

   It is used to get water level in waterlogged areas.

2. ESP8266/LRF24L01 Module

   ESP8266 is a low-cost Wi-Fi chip with full TCP/IP stack and MCU capability. [19]

3. Routers

   Used to accumulate data from different sensors connected in star topology. Sends data to Server via the Internet.

Software requirements are

1. MQTT protocol

   A lightweight messaging protocol for small sensors and mobile devices, optimized for high-latency or unreliable networks[6].

2. Exotel/Twilio API

   Twilio/Exotel is a communications platform for building SMS,Voice & Messaging applications[20].

3. Google App Engine
   a. Used to deploy backend server
4. Google PubSub
   a. Acts as MQTT broker
   b. Redirects data to Bigquery
5. Firebase
   a. Used to deploy website
6. Dialog Flow
   a. Used to implement chatbots

3.5 Selection of the Hardware, Software , Technology and tools

Identification Module:Sensors are deployed using a star topology. Sensors capture the water level data using ultrasonic sensors. This data is captured to the router. The router forwards the data to the gateway router which in turn transmits the data to the server. Water level data,latitude and longitude is used to pinpoint the area of waterlogging.

Analysis Module: Our proposed algorithm measures score using parameters like water level, tide status and current precipitation amount and identifies the severity of waterlogging.

Prediction Module: Deep neural network is used in this module. Various parameters like previous year rainfall data, previous year waterlogging data are employed for this purpose.

Chapter 4
Proposed Design

4.1 BLOCK DIAGRAM

In block diagram principal parts or main modules are shown along with the relationships among them. In proposed system as shown in figure 4.1 all the sensor installed will pass the data to the database from there it will be given input to Analysis module.Based upon the output of the Analysis authorities will get notified. Reports and graphs will be given on the front end for graphical understanding of output.

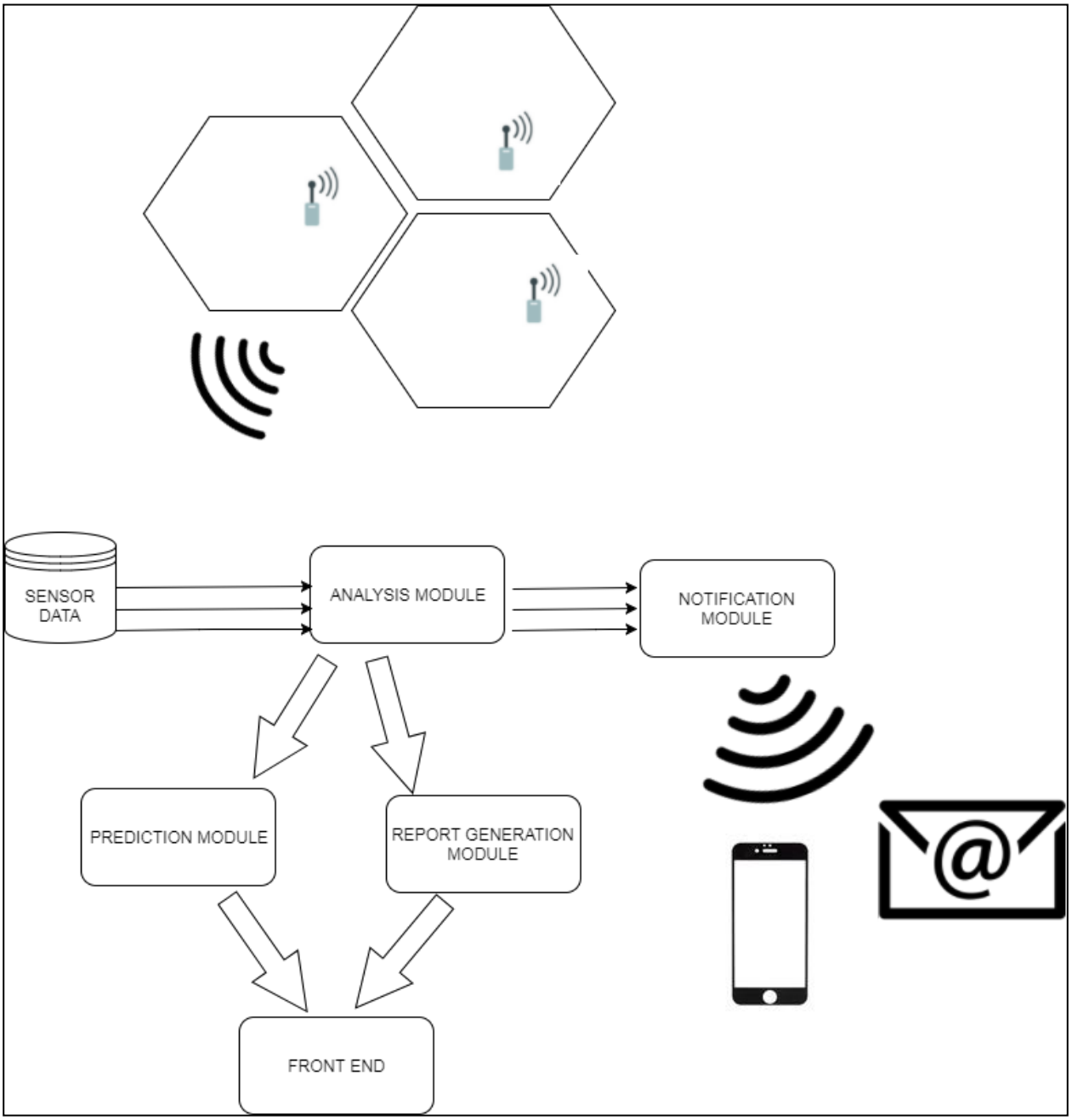


Figure 4.1 : Block diagram

A proposed system will web based platform which is based on 6 main modules which are :

1. Location mapping

   In Location mapping module based upon the longitude and latitude of the area Identification of the location and Mapping area to officer will be done ,so the output will be Location details and officer details.

2. Identification module

   In Identification module depending on factors like water level , current rainfall data and location details waterlogging will be identified and based on the thresholds it will be divided into categories of normal ,low , moderate , high and critical.

3. Prediction module

   In Prediction module based upon the current and past rainfall data , previous years water level data will be predicted and error rate will be calculated based upon the comparisons with calculated water level data for the previous years and the actual calculated value.

4. Analysis module

   In Analysis module weather data , precursory waterlogging results will be provide and severity levels which are Normal , low , mid range and Danger along with the actions will be given as output.

5. Notification module

   In this module SMS notifications , EMAIL notifications and push notifications will be given to the Authorities based upon the waterlogging level and severity.

6. Evaluation and reports

   In Evaluation and reports module Graphs and Reports will be provided based upon the error rate , severity.

4.2 MODULAR DIAGRAM

Modular Design, is a design approach that subdivides a system into smaller parts called modules or skids, that can be independently created and then used in different systems. A modular system can be characterized by functional partitioning into discrete scalable, reusable modules; rigorous use of well-defined modular interfaces; and making use of industry standards for interfaces. Besides reduction in cost (due to less customization, and shorter learning time), and flexibility in design, modularity offers other benefits such as augmentation (adding new solution by merely plugging in a new module), and exclusion.

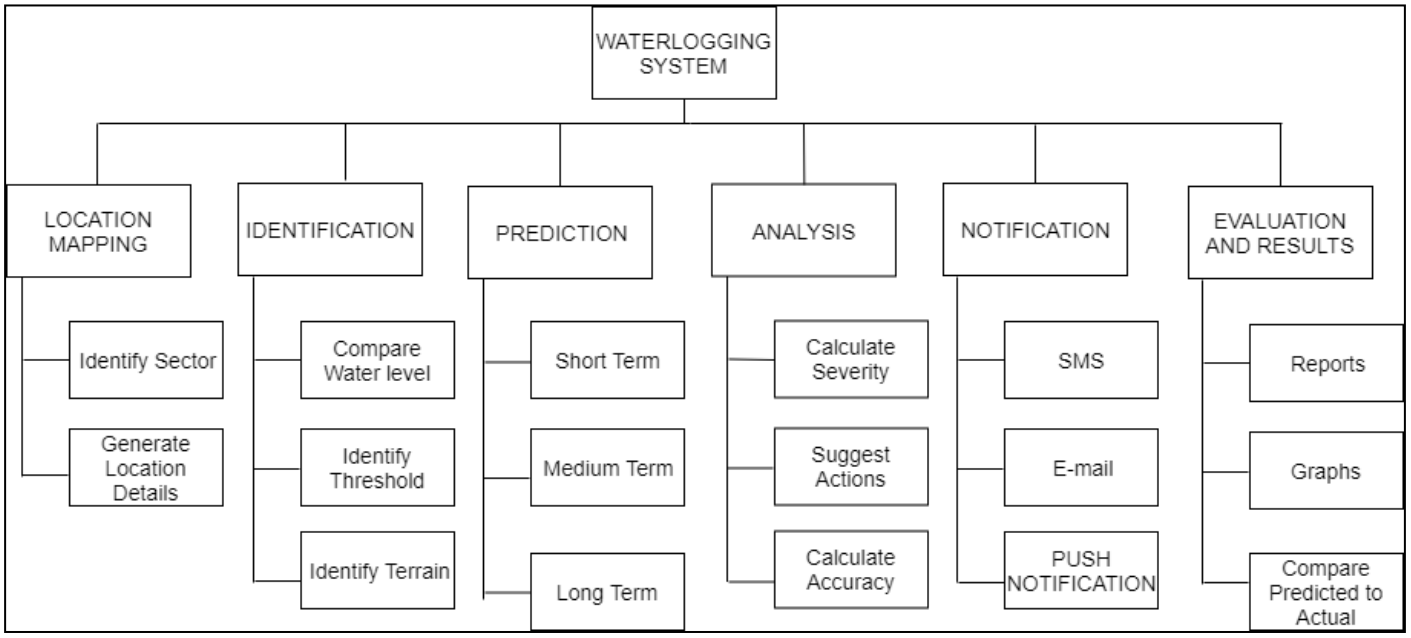


Figure 4.2 : Modular diagram

The above figure 4.2 gives an brief overview of the BMC waterlogging system which will include modules such as Location mapping, Waterlogging Identification, Analysis, Notification, Prediction. It will also include evaluation of results.

Location Mapping module

In Location mapping module Figure 4.3 based upon the longitude and latitude of the area Identification of the location and Mapping area to officer will be done ,so the output will be Location details and officer details. It also includes mapping of location name with officer details like officer name, contact number, email id provided by BMC.

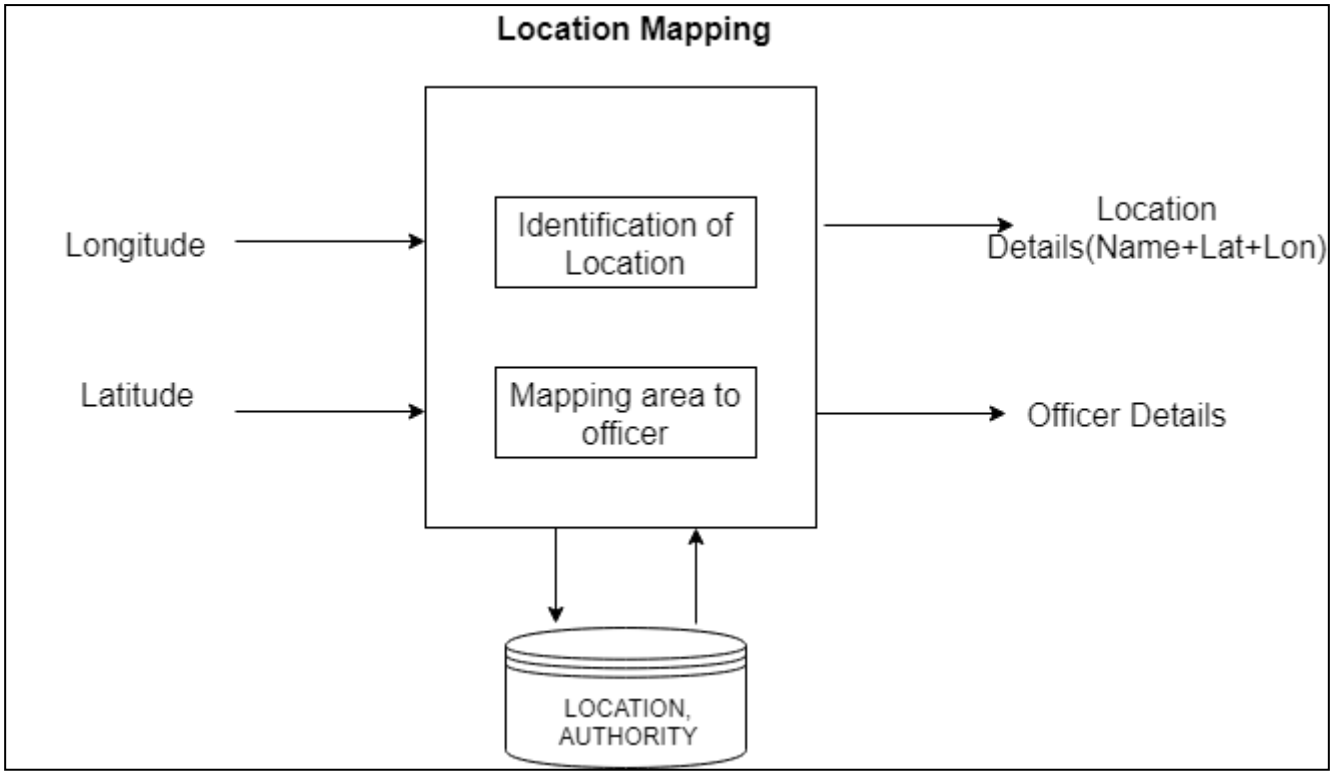


Figure 4.3 : Location Mapping Module

Identification Module

The Identification module Figure 4.4 will identify the waterlogging in particular area, from each area water level will be taken and then compared to the thresholds to determine the status of waterlogging as normal , low , medium and high. The inputs to the Identification Module include -water level, current rainfall data, location details. It also includes date, time, drainage, season and tides schedule.

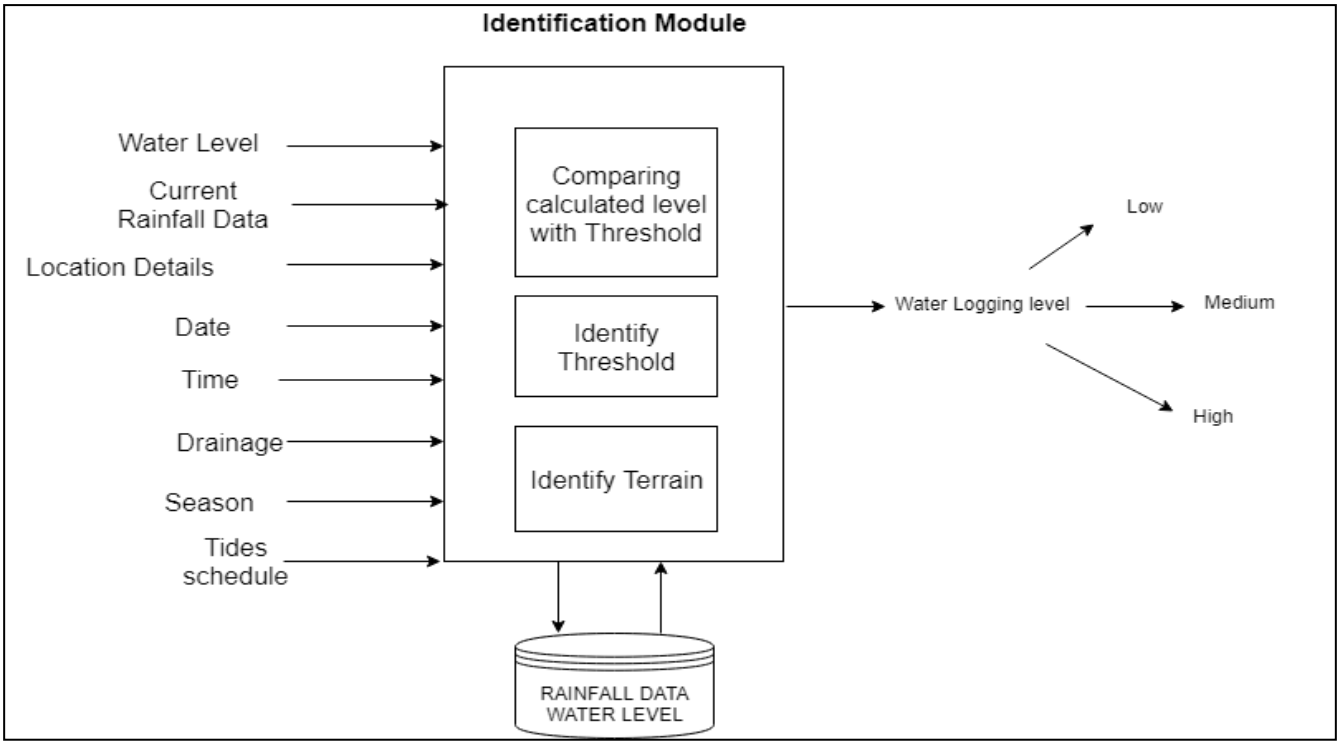


Figure 4.4 : Identification Module

Evaluation and Reports

In Evaluation and reports module Figure:4.5 Graphs and Reports will be provided based upon the error rate , severity. The input to this module also includes current+past water level, rainfall data, location details, date and time. The graphs generated will be of Year vs Efficiency, Top 10 water prone areas and Weakly Region wise Reports.

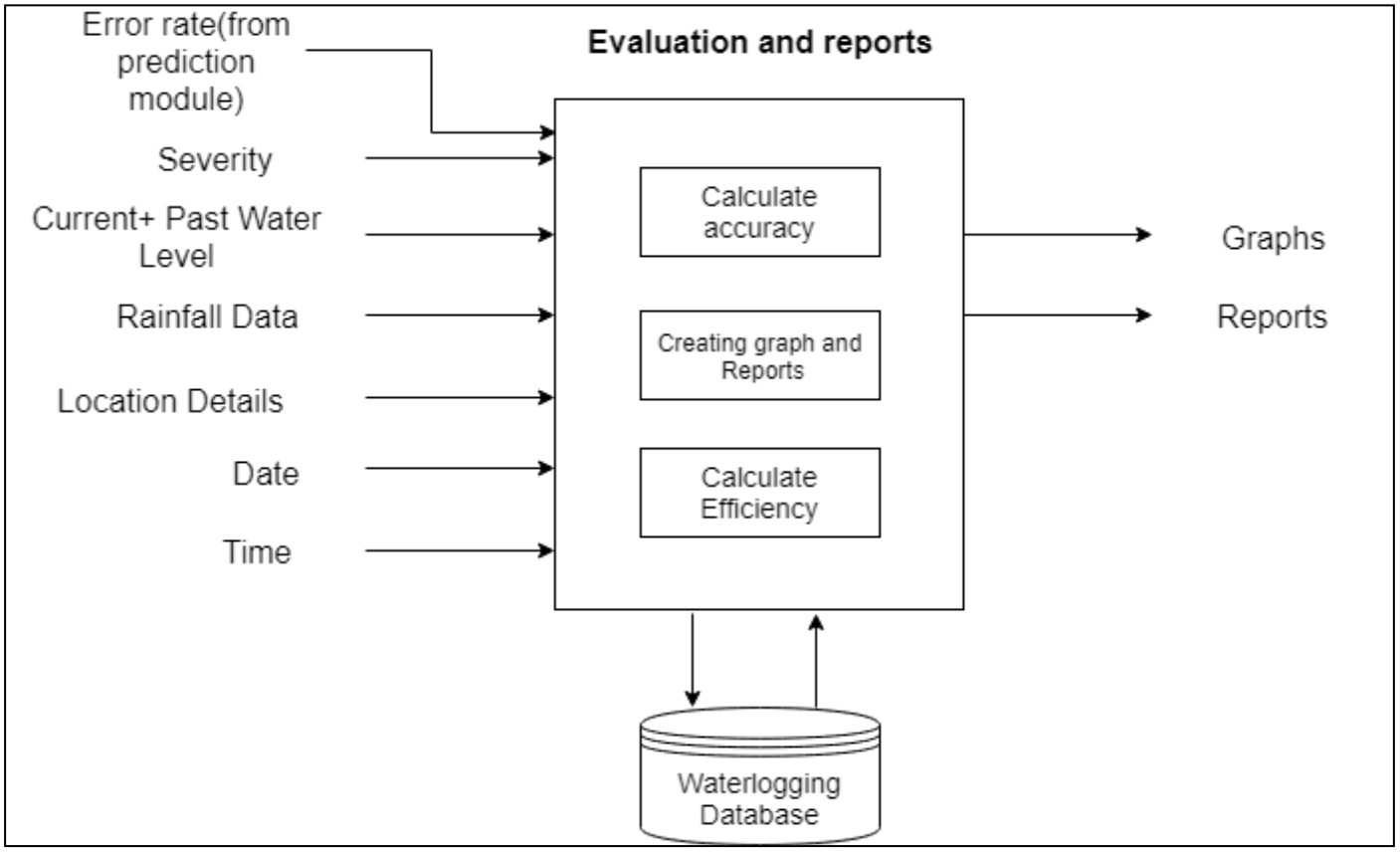


Figure 4.5 : Evaluation and Reports Module

Prediction Module

In Prediction Module module Figure 4.6 based upon the current and past rainfall data , previous year prediction data water level will be predicted and comparisons with actual value will be done afterwards to calculate error rate.

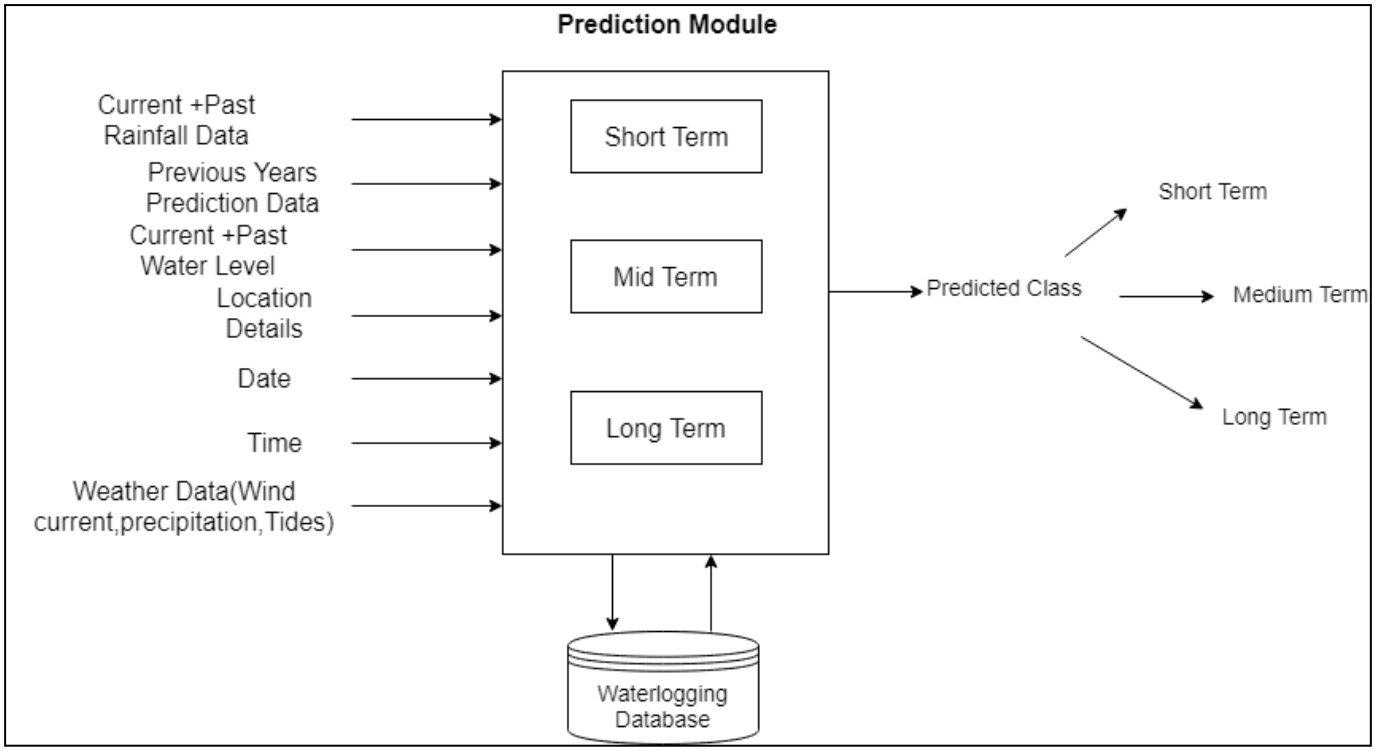


Figure 4.6 : Prediction Module

4.3 Detailed Design

Data Flow Diagrams

Data flow diagram is a graphical representation of the flow of the data inside the system across various modules. A DFD is often used as a preliminary step to create an overview of the system without going into great detail, which can later be elaborated. A DFD shows what kind of information will be input to and output from the system, how the data will advance through the system, and where the data will be stored.

DFD LEVEL 0:

A level 0 DFD gives the overall presentation of the system with its main modules and general structure.Here in figure 4.7 system will get the data from sensor , weather department and BMC cleaning department and based upon the identification , analysis and predictions BMC officials will be notified.

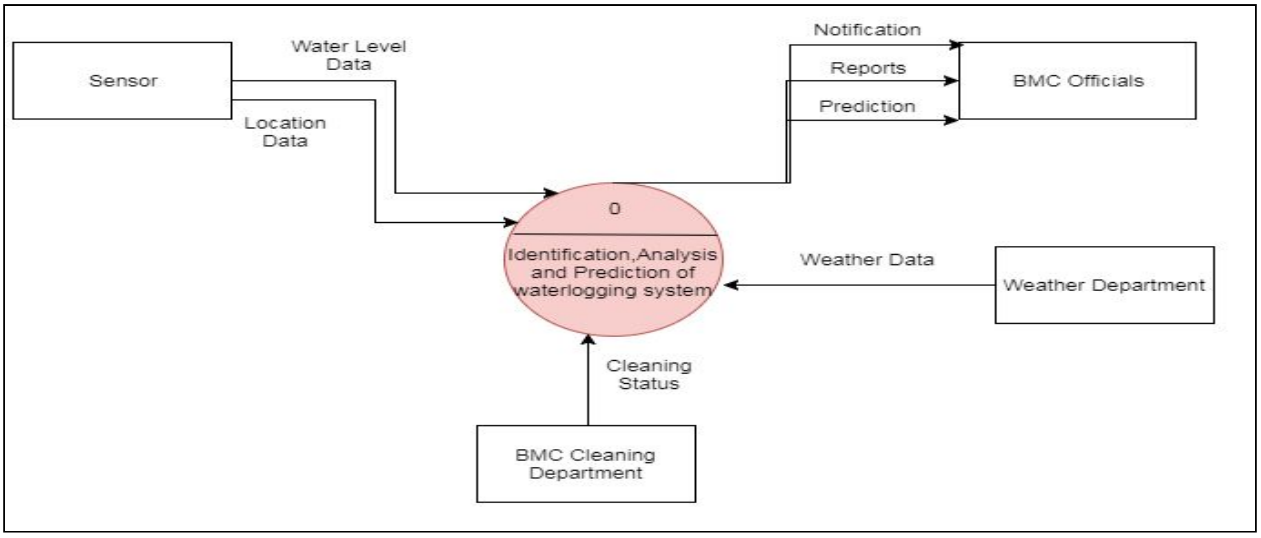


Figure 4.7 : DFD LEVEL 0

DFD LEVEL 1 :

Whereas in level 0 DFD we just give general structure of the system , in level 1 DFD we provide detailed overview with respect to each module.Here in figure 4.8 , all the six main modules are shown along with the flow the data. Databases are also used which are water level , predictions etc.

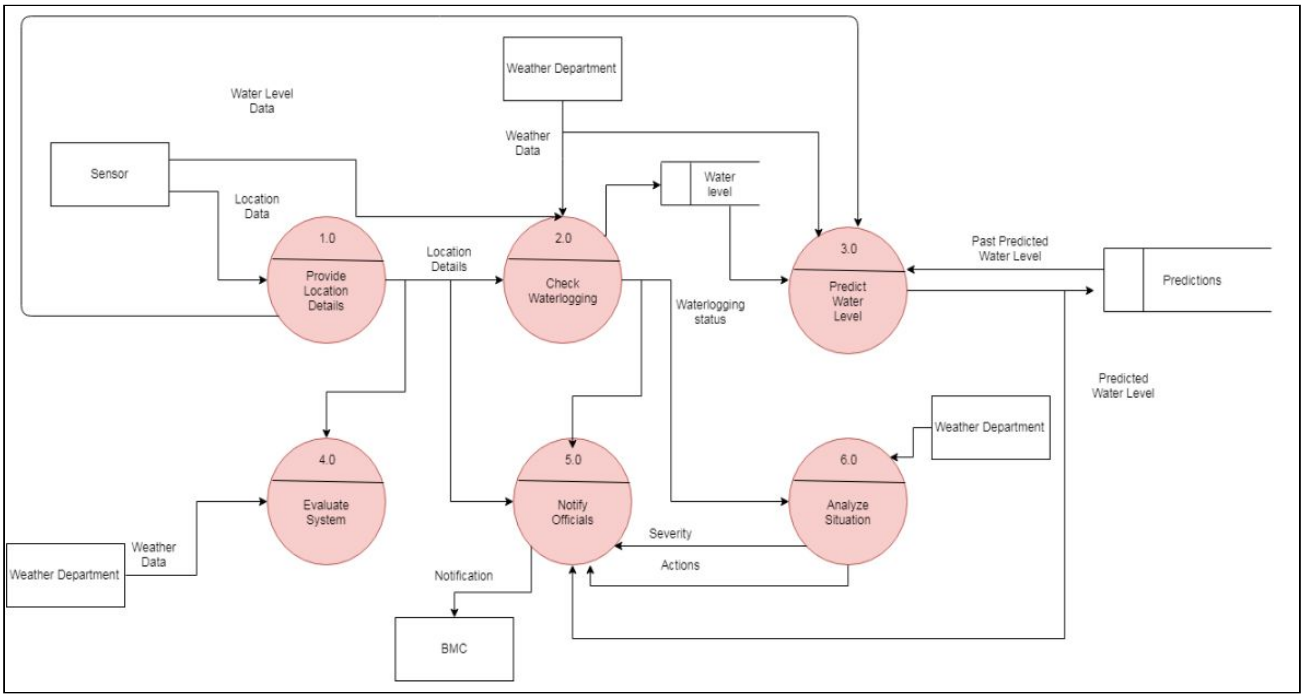


Figure 4.8 : DFD LEVEL 1

DFD LEVEL 2 : Location Mapping

In DFD level 2 each individual modules has be shown along with the inputs and databases , In Location Mapping module data from various sector will be used to map the area with respective area authority.After that location details will be provided as output for further modules.

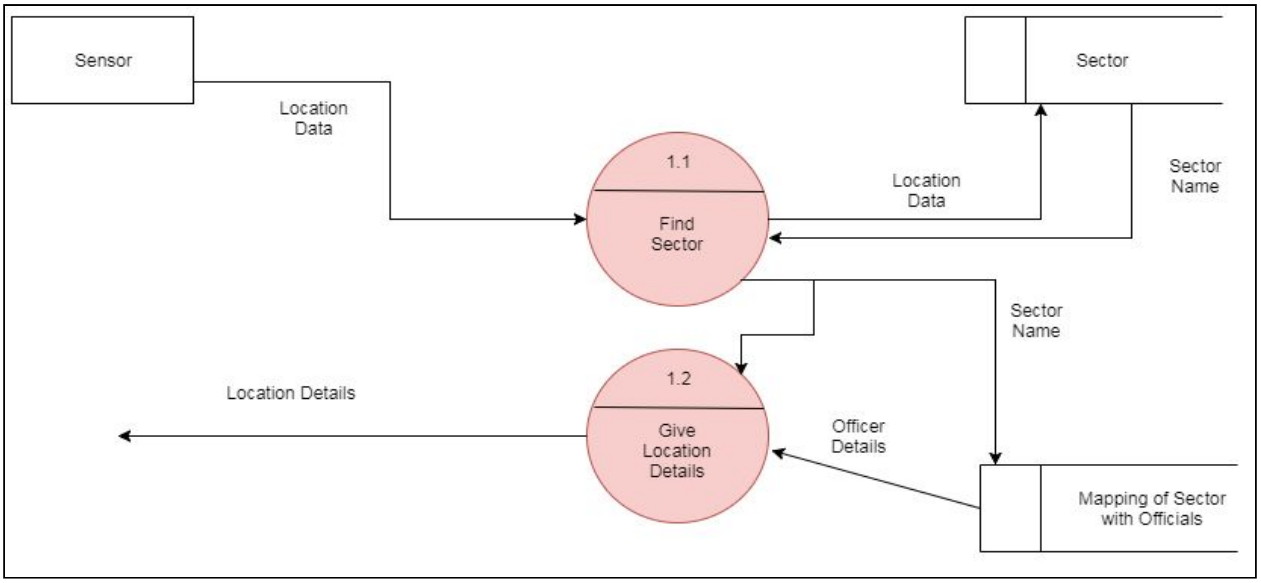


Figure 4.9 : DFD LEVEL 2 : LOCATION MAPPING

DFD LEVEL 2 : Identification

In Identification module there are subprocesses such as identify terrain , identify thresholds which will be completely depend upon the location details.After comparing current water level with threshold system will identify waterlogging .

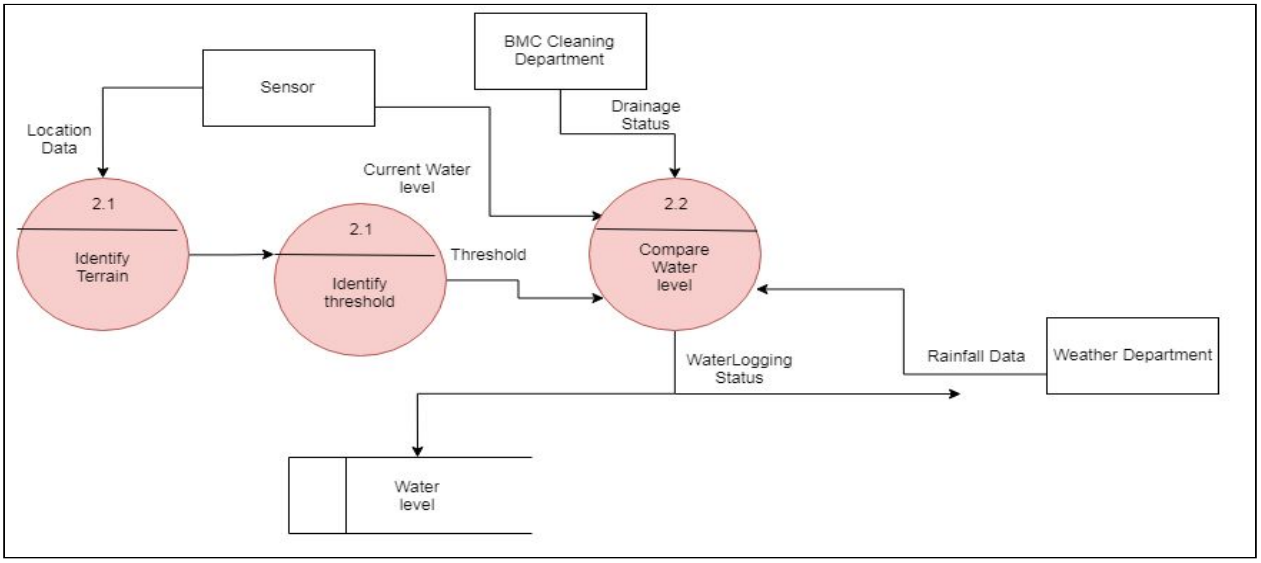


Figure 4.10 : DFD LEVEL 2 : IDENTIFICATION

DFD LEVEL 2 : Analysis

In Analysis module waterlogging level is main input for the analysis. Apart from it other inputs form weather department such as rainfall data ,High tides schedule are also required. There are two things are provided as output first one is severity level and second one is actions to be taken. Here two main databases are used severity indicator for the threshold and suggested measure to give action based upon the analysis.

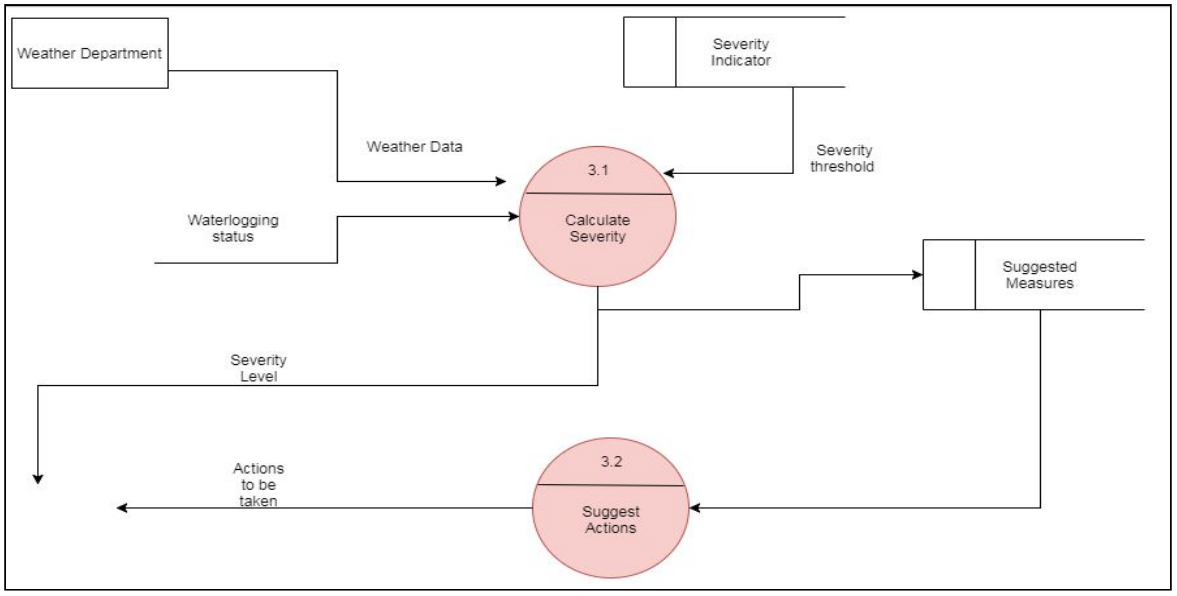


Figure 4.11 : DFD LEVEL 2 : Analysis

DFD LEVEL 2 : Evaluation and Reports

In this module based upon the error rate severity Graphical analysis of the output will be done .There two main outputs Reports and Graphs.Report will contain the information about waterlogging levels action taken .While graphs are of Year vs Efficiency , Top 10 water prone areas and Weakly Region wise Reports.

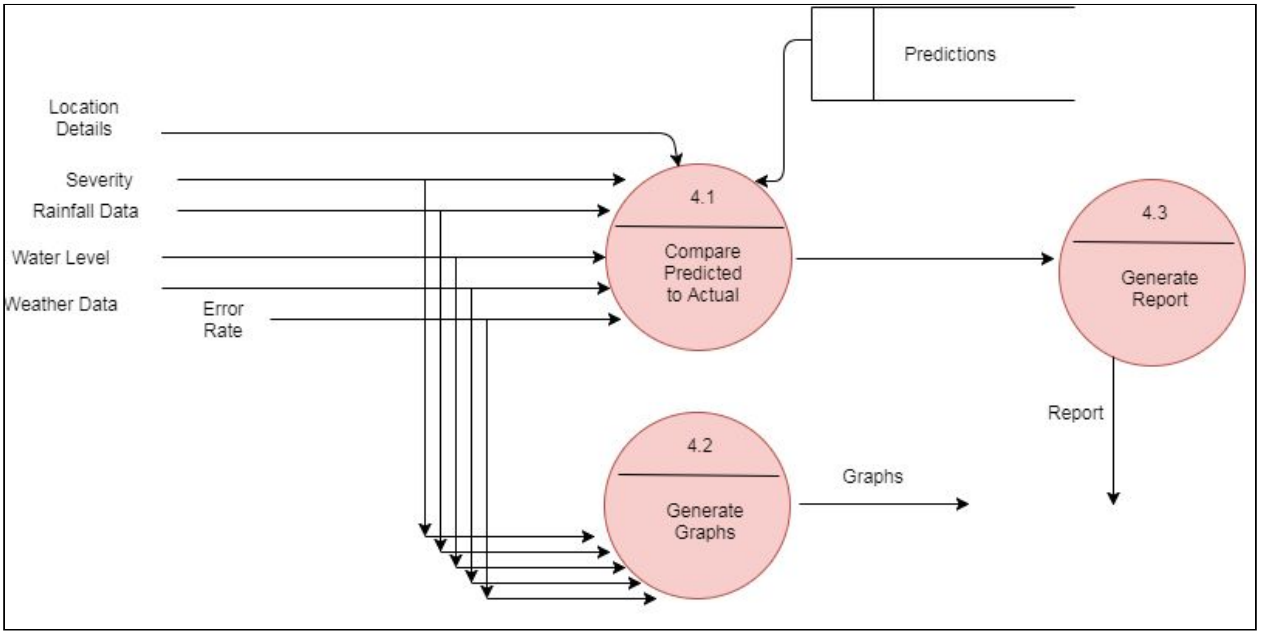


Figure 4.12 : DFD LEVEL 2 : EVALUATION AND REPORTS

FLOWCHART OF THE SYSTEM DEVELOPED:

A flowchart is a type of diagram that represents an algorithm, workflow or process, showing the steps as boxes of various kinds, and their order by connecting them with arrows. This diagrammatic representation illustrates a solution model to a given problem.

As shown in the figure 4.13, it shows a flow of steps that take place in order to solve waterlogging problem occurring in an area.

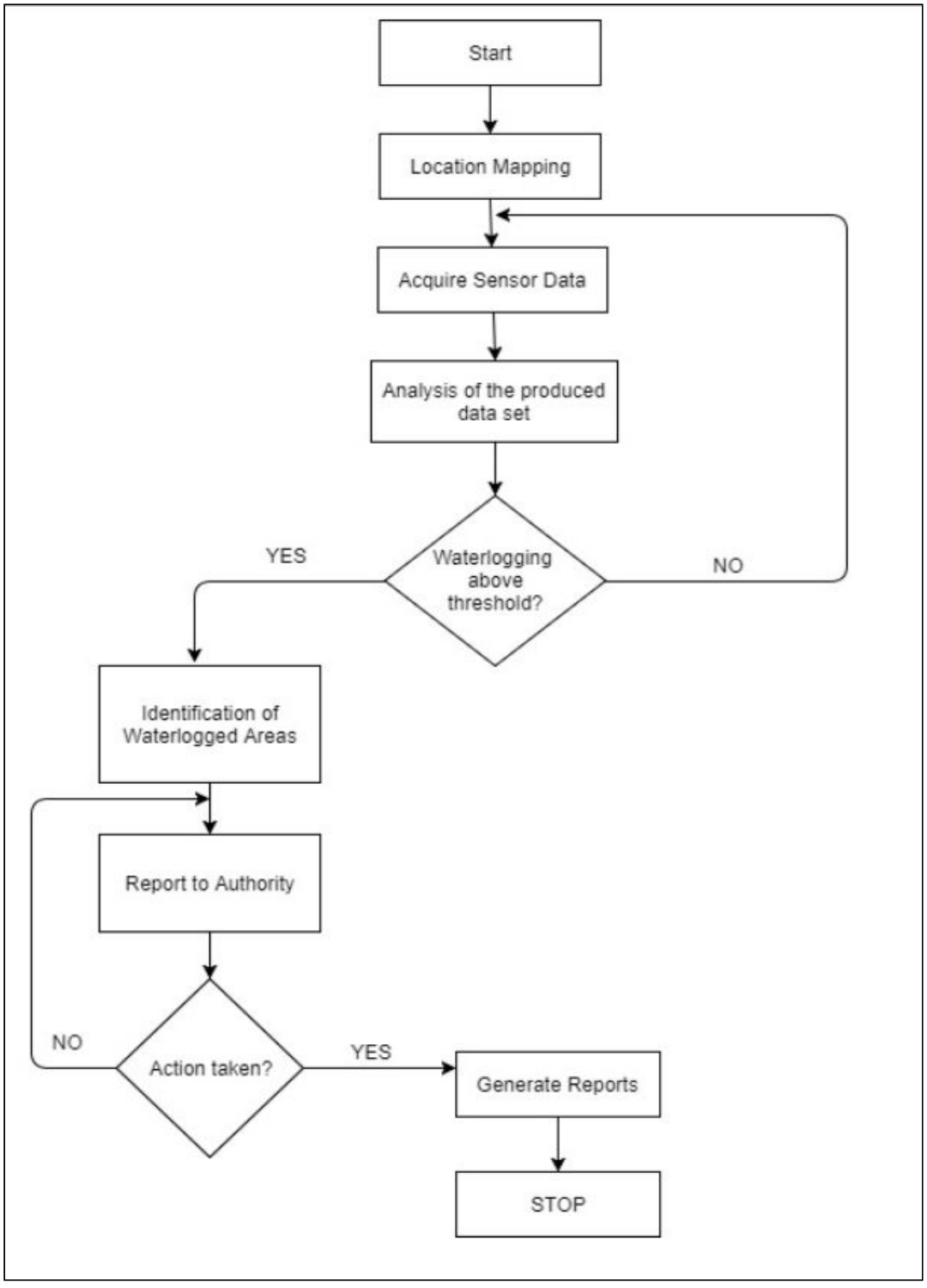


Figure 4.13 : Flow Chart of the system developed

ACTIVITY DIAGRAM

Activity diagrams are graphical representations of workflows of stepwise activities and actions with support for choice, iteration and concurrency. As shown in the figure 4.14, a graphical representation of workflow is presented wherein how various activities flow in order to achieve a certain goal to report the waterlogged areas to the authorized user.

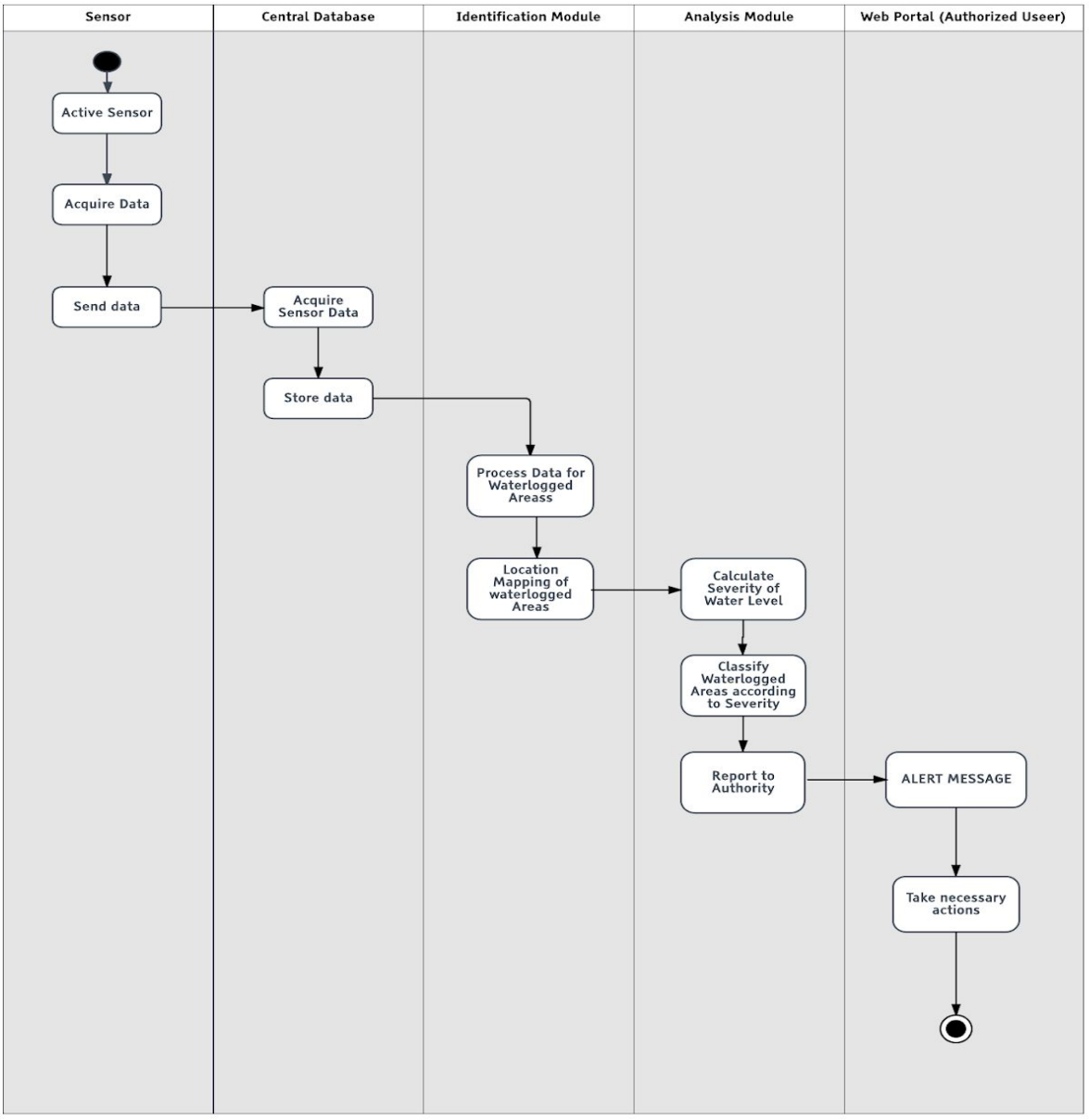


Figure 4.14 : Activity Diagram

ER Diagram

An entity relationship diagram (ERD) shows the relationships of entity sets stored in a database. An entity in this context is a component of data. In other words, ER diagrams illustrate the logical structure of databases. At first glance an entity relationship diagram looks very much like a flowchart. It is the specialized symbols, and the meanings of those symbols, that make it unique. Figure 4.15 shows the ER diagram of our proposed system. Sensor has attributes like sensor_id,latitude,longitude and water level. BMC cleaning department has attributes like area_id(primary key), date, status of cleaning. This entity sends data to the central database. Weather department is another important entity with attributes like data,area_id, time and data(including rainfall data, tide status). User entity has attributes like user_id, user_name, user_email and user_phone.

Online BMC portal is related to user(BMC officials) via Send notification.

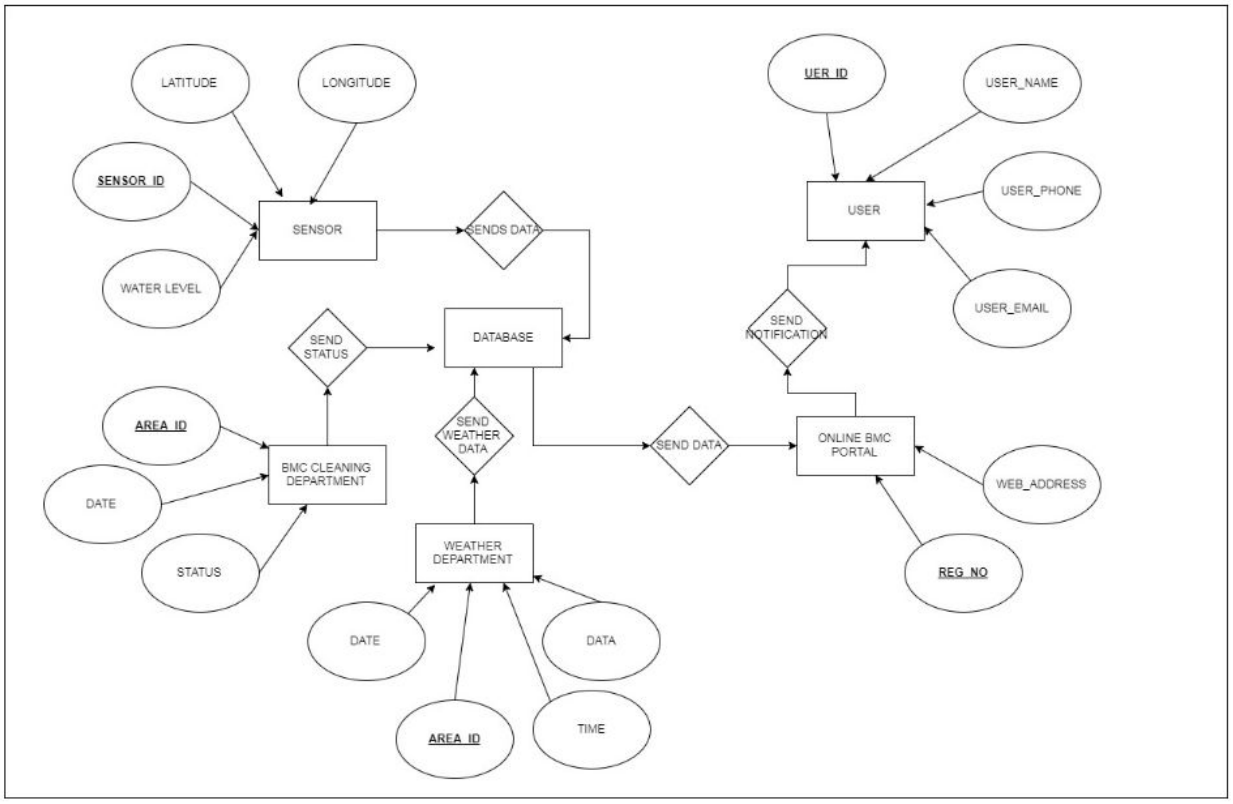


Figure 4.15 : ER Diagram

4.4 Project Scheduling & Tracking using Timeline / Gantt Chart

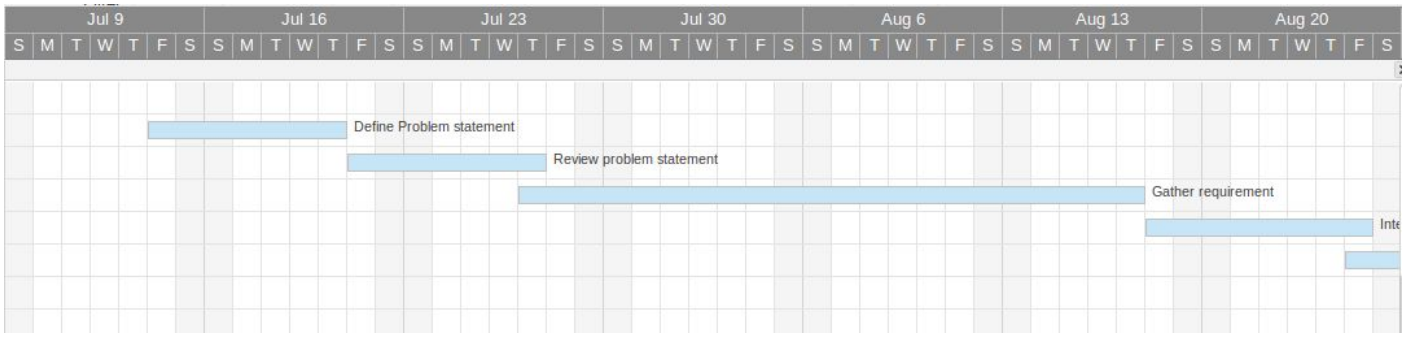
Gantt chart is used for the project scheduling and illustrating the project timeline.We can create it using the dening the Task Number and Task name.It also require some additional columns like start date , End date , Predecessors of an Task and status of the task in order to show the completeness of the task.

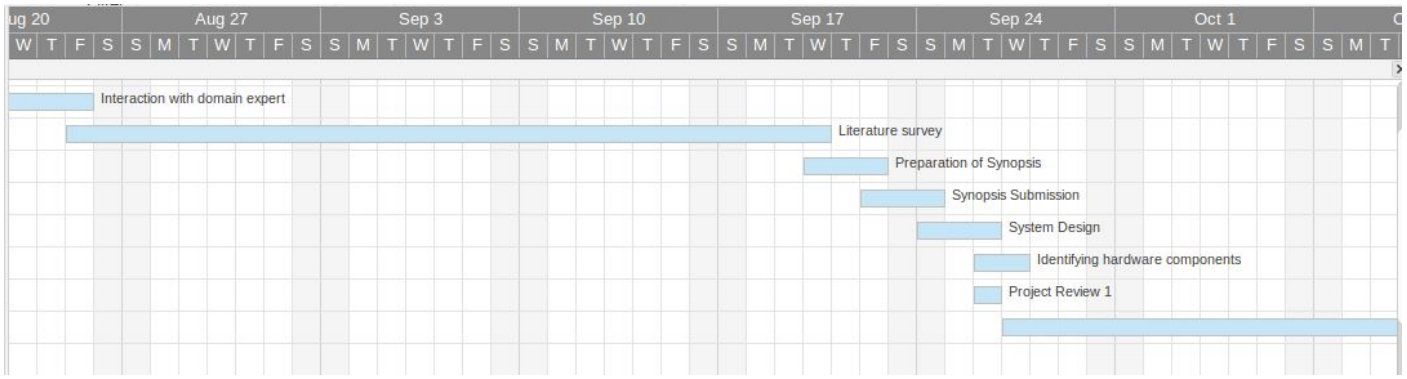
	Task Number	Task Name	Start	End	Predecessors	Status
1	1	Define Problem statement	07/14/17	07/20/17		Completed
2	2	Review problem statement	07/21/17	07/27/17	1	
3	3	Gather requirement	07/27/17	08/17/17	1,2	Completed
4	4	Interaction with domain expert	08/18/17	08/25/17	2	Completed
5	5	Literature survey	08/25/17	09/20/17	1,4	Completed
6	6	Preparation of Synopsis	09/20/17	09/22/17	5	Completed
7	7	Synopsis Submission	09/22/17	09/24/17	6	Completed
8	8	System Design	09/24/17	09/26/17	7	Completed
9	9	Identifying hardware components	09/26/17	09/27/17	7	Completed
10	10	Project Review 1	09/26/17	09/26/17	7	Completed
11	11	Changes in system after Review	09/27/17	10/23/17	10	Completed
12	12	Project Review 2	10/27/17	10/27/17	11	Completed
13	13	Design Database	11/01/17	11/10/17	7	Completed
14	14	UI Design	11/11/17	11/17/17	7	Completed
15	15	Coding of Identification Page	11/18/17	11/27/17	7	Completed
16	16	Identifying and Finalising Neural Net	11/28/17	12/10/17	7	Completed
17	17	Training neural net	12/11/17	12/20/17	17	Completed
18	18	Coding of Prediction Page	12/21/17	12/30/17	7	Completed
19	19	Coding of Reports and Results page	01/01/18	01/15/18	7	Completed
20	20	Configure Twilio/Exotel	01/16/18	01/25/18	7	Completed
21	21	Code backend scripts	01/25/18	02/15/18	7	Completed
22	22	Create sensor prototype and set up a	02/16/18	02/28/18	9	Completed
23	23	Integration of Modules	03/01/18	03/15/18	16,18,19	Completed
24	24	Unit Testing	03/16/18	03/31/18	23	Completed
25	25	Develop System manual	04/01/18	04/10/18	23	Completed
26	26	Review and feedback	04/11/18	04/26/18	24	Completed

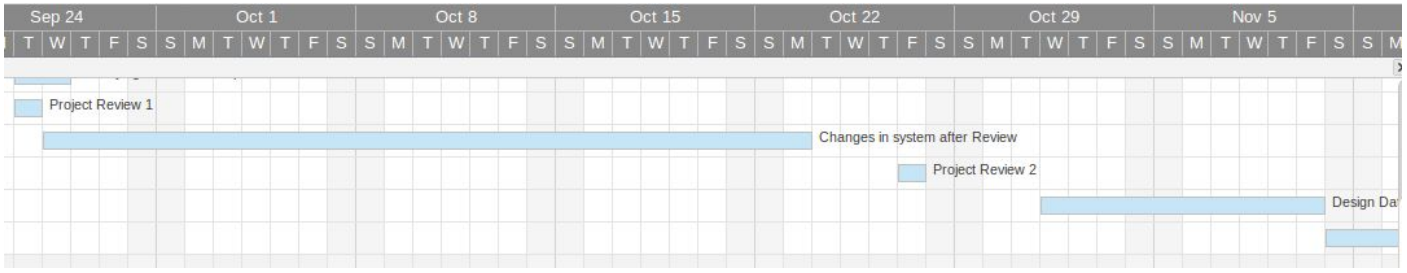
Table 4.1 : Gantt Chart

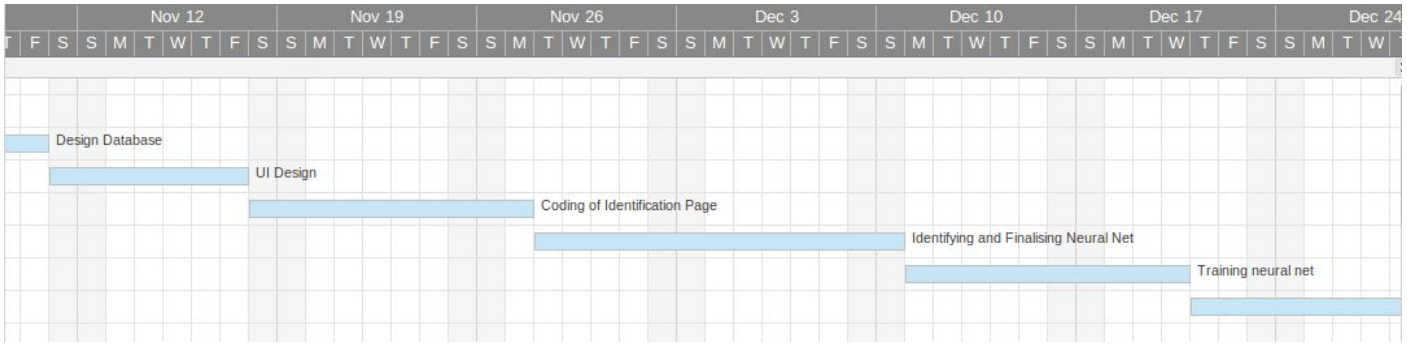
Gantt View

We can generate timeline which illustrates the actual flow of the tasks around the date.Based on the start date and end date it shows it on timeline by using time in x - axis and flow the task on y - axis.Every task except the first one requires an predecessors.Predecessors are basically the the task that needs to be completed before starting the current task.This comes very helpful when we work in a team so that before starting to an module we can check whether its predecessors have been done in order to complete it.


Jul 9
Jul 16
Jul 23
Jul 30
Aug 6
Aug 13
Aug 20
Define Problem statement
Review problem statement
Gather requirement


Aug 27
Sep 3
Sep 10
Sep 17
Sep 24
Oct 1
Interaction with domain expert
Literature survey
Preparation of Synopsis
Synopsis Submission
System Design
Identifying hardware components
Project Review 1


Sep 24
Oct 1
Oct 8
Oct 15
Oct 22
Oct 29
Nov 5
Project Review 1
Changes in system after Review
Project Review 2


Nov 12
Nov 19
Nov 26
Dec 3
Dec 10
Dec 17
Design Database
UI Design
Coding of Identification Page
Identifying and Finalising Neural Net
Training neural net

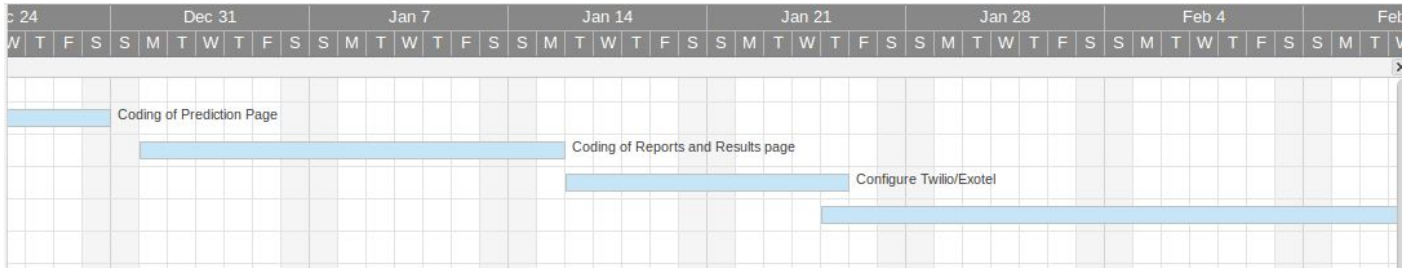

Dec 31
Jan 7
Jan 14
Jan 21
Jan 28
Feb 4
Coding of Prediction Page
Coding of Reports and Results page
Configure Twilio/Exotel

Figure 4.16 : Gantt View

CHAPTER 5
IMPLEMENTATION

For the Implementation of the proposed system there are two major partition , one is software part and other one is hardware part.For the Software part we have used several languages like HTML , Node Js etc. and for the cloud we have used Google Cloud Platform (GCP). For the development of the hardware side we have used Mongoose OS software.

5.1 Algorithms for the respective modules developed

For the several modules we have used some self defined and predefined algorithm .The only predefined algorithm is the decision tree algorithm.All the other algorithms are self defined and have been mentioned below.

a. Algorithm to calculate distance

The distance is calculated using an ultrasonic sensor which provides an real time identification for the system. To start the algorithm , after an fixed time interval esp8266 sends an trigger to the ultrasonic sensor , after receiving an trigger command from the esp8266 ultrasonic sensor sends a wave to the vertically downward direction and starts the timer , after receiving the same wave after some time duration ultrasonic sensor calculates the time duration taken by it and calculate the distance based upon that.Then it sends back the calculated distance to esp8266 via echo and then esp8266 sends the data to server along with some other parameters like sector_id , timestamp and severity.The algorithm is as follows:

```
1. function calculateDistance()
2.     send trigger to ultrasonic sensor
3.     send the ultrasonic wave and start the timer
4.     on receiving the wave stop timer
5.     calculate duration = start - end
6.     distance = (duration / 2 ) / 29.1
7.     return distance
8. end function
```

b. Algorithm for Identification

To identify whether the area is waterlogged or not we mainly depend on the reading received from the sensors.The area will be classified into three main category of the High waterlogged area , Medium waterlogged area or a low waterlogged area.To identify it will collect the data from the sensor , get the current rainfall from the weather API and the threshold rainfall.Based on the following algorithm it will identify the area properly.

```
1.  procedure Identify_level(area)
2.    for all sectors in area do
3.       cWL ← get water level from sensor
4.       cRF ← get current rainfall status from weather API
5.       thr ← rainfall threshold
6.       if(cWL > 0) then
7.          if(cRF > thr) then
8.             if(cWL > 15) then output= high
9.             else if(cWL<15 & cWL>5) then output=medium
10.            else output= low
11.         else output = false reading
12.      else output = no waterlogging
13.      end of the for loop
14.  return output[]
15.  End
```

c. Algorithm for Prediction

Decision tree algorithm is being used to predict waterlogging. The input parameters are rain,rain rate and the tide level(in metres). The target label is water_level which has three values,i.e high,medium and low.For the prediction module the api form the IBM Cloud will be called where the model has been deployed. Based upon the pretrained model it will predict the output depending the parameters inserted.

```
1.  function prediction()
2.     get the parameters
3.     param = rain , rain rate , tide level
4.     put the input to the pre trained model
5.     model will classify it into low , medium and high based on the input
6.     return the class
7.  end function
```

5.2 Comparative Analysis with the existing algorithms

Currently in the mumbai region to deal with the waterlogging problem ,the officials mainly depends on the phone call made by the local people which is very inefficient and since they do not have the real time tracking system so it becomes hectic to handle incase of the major problems.

The one of the current working system in the world is used by an USA government which Storm Water Management Model (SWMM) which is developed by United States EPA in 1971. SWMM model is used for the planning, analysis, and design related to stormwater runoff, combined and sanitary sewers, and other drainage systems in urban areas .SWMM is amongst one of the numerous hydrological transport prototypes which has been used by prominent agencies and through advisers and institutes throughout the planet.

Parameters	SWMM Model	Proposed System
1. Real Time Identification	Only based on inflow and outflow of the rainwater	Based on the sensor data , rainfall data and tides schedule
2. Capabilities	Time - varying rainfall , handle drainage system of unlimited size ,	Real time Identification , Prediction for the coming days , Notification
3. Development	It consists of C engine code and also delphi code that can be easily imitated and transcribed by students	GCP used for backend and HTML and Node Js for the frontend and api calls
4. Model parameter	Based on drainage system , rainfall	Based on rainfall , rain rate and tides schedule

Table 5.1 : Comparison between SWMM and proposed system

5.3. Evaluation of the developed system

For the developed system there are various modules involved and for each modul there are various parameters of evaluation.The evaluation basically includes the accuracy , Recall and efficiency of the developed system.The developed system contains the four evaluable modules which are Identification module , Prediction module , Facebook reporting module and Notification module.The evaluation is done based upon the performance of the particular module and the main subparts of the module that it mainly consists of.

Identification module

The main part of the identification module is real time identification which is provided by the sensors , so the main accuracy the Identification module depends on the accuracy of the ultrasonic sensor.The error rate for the ultrasonic sensor that we have used is 0.05 %.

It has minimum range of at most 2 cm and maximum range is 4 meters , according to our need we will mostly require the range of 1 meters to the 3 meters

Prediction Module:

In the prediction module we have used the rainfall dataset of the previous years , it was supervised learning model which means that the we have provided the labels for the prediction the future data.We have used the weka in order to calculate the accuracy of the model.

The output from weka can be shown as following , here based upon the number of input rows the output is determined.Here TP rate indicates the true positive rate in the dataset , FP rate is the false positive rate .The recall value is calculated as the tp rate divided by the sum of the true positive and the false negatives.

The accuracy is calculated as the ratio of the sum of the true positive and true negative divided by the sum of the true positive , true negative , false positive and the false negative

```
=== Summary ===

Correctly Classified Instances       12996               94.9931 %
Incorrectly Classified Instances       685                5.0069 %
Kappa statistic                          0.5657
Mean absolute error                      0.0599
Root mean squared error                  0.1729
Relative absolute error                 64.9326 %
Root relative squared error             82.0428 %
Coverage of cases (0.95 level)          96.4915 %
Mean rel. region size (0.95 level)      35.034  %
Total Number of Instances            13681

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Recall   ROC Area  PRC Area  Class
                 0.984    0.493    0.984    0.745     0.962     1
                 0.000    0.000    0.000    0.526     0.008     2
                 0.570    0.016    0.570    0.777     0.430     3
Weighted Avg.    0.950    0.459    0.950    0.746     0.921

=== Confusion Matrix ===

     a     b     c   <-- classified as
 12503     0   205 |     a = 1
   108     0     0 |     b = 2
   372     0   493 |     c = 3
```

Figure 5.1. Prediction summary

Facebook Reporting

The Facebook Reporting module is where the user can report the waterlogging in the native area through facebook chatbot.The backend for this particular module is handled by the Dialog Flow by Google and Google Cloud functions, hence this produce an high performance service.

Notification

For the notification of the waterlogging to the particular officer of the assigned area Twilio APIs have been used . Twilio is an platform where any user can send the perform actions like building SMS, Voice & Messaging applications on an API built for global scale Twilio APIs to send text messages from the server to the intended recipient. The official documentation specifies 30 seconds as maximum delay.

Chapter 6
Testing

Software testing is one of the stages where the total functionality of the developed system is tested. In terms of human beings, testing tells what level of knowledge or skill has been acquired. In computer hardware and software development, testing is used at key checkpoints in the overall process to determine whether objectives are being met. For example, in software development, product objectives are sometimes tested by product user representatives. When the design is complete, coding follows and the finished code is then tested at the unit or module level by each programmer; at the component level by the group of programmers involved; and at the system level when all components are combined together. At early or late stages, a product or service may also be tested for usability.

6.1 Integration Testing

After developing its models it becomes very important to test whether the whole bunch of modules will act as a single system , show integration testing basically check weather the all models will walk as a cym as a single system. In integration testing we start grouping the two models and continue doing for the rest of the modules. It occurs after unit testing and before validation testing. Integration testing takes as its input modules that have been unit tested, groups them in larger aggregates, applies tests defined in an integration test plan to those aggregates, and delivers as its output the integrated system ready for System testing.

Each of the modules namely, identification, prediction and notification were integrated and tested for bugs and error. After resolving a few minor bugs, the modules worked perfectly fine.

6.2 Functional Testing

It is a software testing process used within software development in which software is tested to ensure that it conforms with all requirements.It checks the functionality of each modules defined and made by developer

One of the most important requirement given by the BMC officers was real time identification of waterlogged areas. The given system fulfills all the primary requirements given to us. However, few more changes have been suggested which is beyond the scope of this project.

6.3 System Testing

System testing is performed on the entire system in the context of a Functional Requirement Specification(s) (FRS) and/or a System Requirement Specification (SRS).System Testing is a level of software testing where a complete and integrated software is tested. The purpose of this test is to evaluate the system’s compliance with the specified requirements.

The developed solution satisfies all the functional and non-functional requirements specifies by BMC.

6.4 Performance Testing

Performance Testing is a type of testing to ensure software applications will perform well under their expected workload.

Features and Functionality supported by a software system is not the only concern. A software application's performance like its response time, reliability, resource usage and scalability do matter. The goal of Performance Testing is not to find bugs but to eliminate performance bottlenecks.

Avg. Throughput-6.18Hits/s

Average throughput: It refers to how many units of information can a system process in a set period of time. It's a measurement of how much bandwidth is required to handle a load (concurrent users and requests). A higher value throughput means the application can handle an increasing number of concurrent users and that's a good thing.

Avg. Response Time-3.21s

Average Response time: This is the most important metric to understand how a website is performing from the user's point of view. In simple terms, the average application response time is the amount of time an application takes to return a request to a user. An application should be tested under different circumstances (i.e. number of concurrent users, number of transactions requested). Typically, this metric is measured from the start of the request to the time the last byte is sent. Other factors, such as geographic location of the user and the complexity of the information being requested, can affect the average response time for users and should be considered in an overall evaluation of application performance. To ensure an optimal user experience, it's essential to have an idea of what a round trip looks like for an application and to make adjustments if the average response time is not up to self-defined standards.

6. 5 Usability Testing

According to the feedback given by the BMC officers, the UI is

- ➢ Clear
- ➢ Concise
- ➢ Familiar
- ➢ Responsive
- ➢ Consistent
- ➢ Efficient and
- ➢ Attractive

6.6 Acceptance Testing

In Acceptance testing the system is tested against the requirement posted by the user.Acceptance Testing is the fourth and last level of software testing performed after System Testing and before making the system available for actual use.Internal Acceptance Testing is performed by members of the organization that developed the software but who are not directly involved in the project (Development or Testing).External Acceptance Testing is performed by people who are not employees of the organization that developed the software.

The developed solution meets most of the requirements. However it couldn't encompass few of the improvements/suggestions given by the BMC officers.

6.7 Regression Testing

Regress testing is the testing process where we test the system after the changes has been done in the system.here we check the functionality of the system after the changes has been has been committed . Regression testing is a normal part of the program development process and, in larger companies, is done by code testing specialists. Test department coders develop code test scenarios and exercises that will test new units of code after they have been written. These test cases form what becomes the *test bucket*.

Messaging via Task App was not a part of the original solution. A discussion with the BMC Officer Mr. Shrikant Rade revealed this requirement. Integration of 'Messaging via Task App' didn't break the existing system. There were few display error which was resolved by debugging the html code.

6.8 Beta Testing

Beta testing is also known as field testing whether the actual system is tested against the low level or local user in order to find out the proper working of the system .The goal of beta testing is to place your application in the hands of real users outside of your own engineering team to discover any flaws or issues from the user's perspective that you would not want to have in your final, released version of the application. Example: Microsoft and many other organizations release beta versions of their products to be tested by users.

A group of 6 BMC officers participated in the Beta testing of the developed system. The following are the comments given by the end users

- The UI is consistent,familiar and responsive
- The FAQ chatbot helps to understand the system better
- The analytics provides a bird's eye view of the entire scenario
- To report waterlogging via Facebook chatbot, the user has to initiate the conversation with 'hello'. However, the BMC officers want to make the reporting easier without having the user to type 'hello'.
- The prediction module provides a clean interface to get forecasting for the critical areas.

Chapter 7
Result Analysis

7.1 Simulation Model

The main module of the proposed system is the real time identification of the waterlogged areas.For the identification of the waterlogged areas the main important part is the to notice the change in the current water level.The working of the ultrasonic sensor has been explained below.

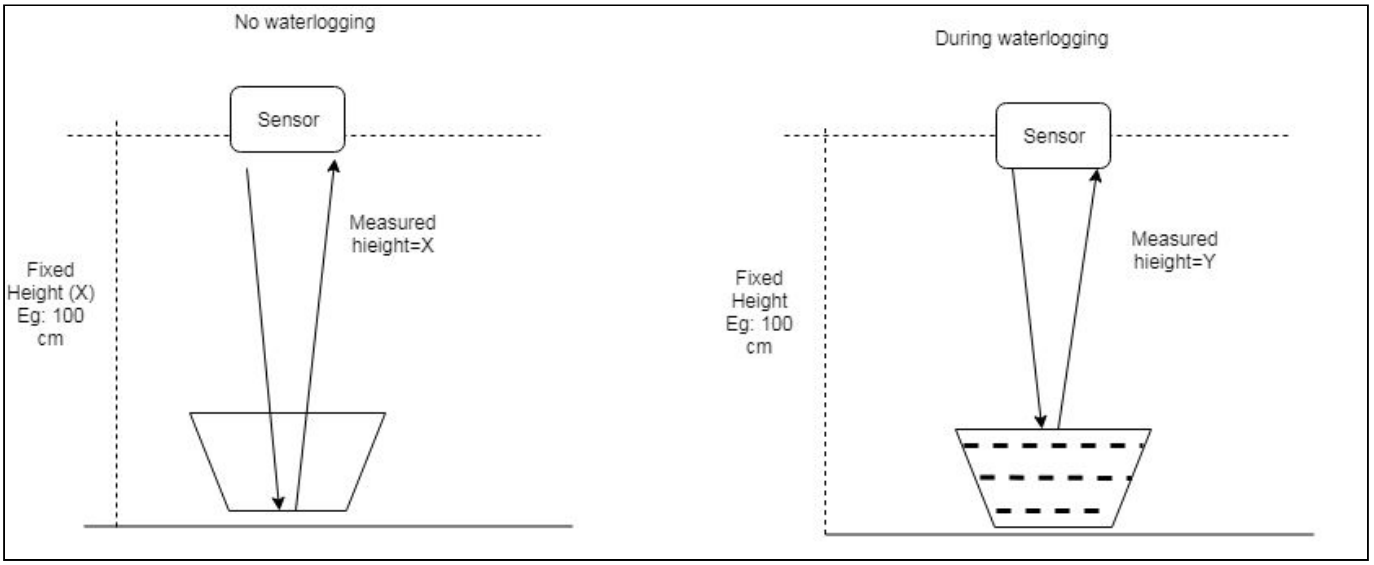


Figure 7.1 : Working of the ultrasonic sensor

When the ultrasonic sensor gets the request from the esp8266 it sends an signal to the ground and takes it back again,Now it measures the time duration taken to get the signal back and based on that it measures the distance of the water level.

To use system user first have to login through first page then user will be redirected to the dashboard page, get user will have the option to move to the another modules like prediction model , notification module , online reporting module. In prediction model for the testing purpose we have provided three input text boxes so that user will able to predict and test it accordingly.

7.2 Parameters Considered

There are various parameters for different models but there are two men models where we require the actual parameters these models are as follows:

Identification

For the identification of the waterlogged areas we have considered the following three parameters because the study area is near to the coastline. The tide parameter is added due to the area is close to the coastline we can ignore the tide parameter if the area is unaffected by the tide schedule.

- Tide
- Rainfall
- Water logging level reported by sensors

Prediction

For the prediction module we have got dataset that includes various factors like temperature , rain , rain rate , atmospheric pressure etc, but after constructing the decision tree there were only three main parameters remains which are as following :

- Rain rate
- Rainfall
- Tide level

7.3 Screenshots of User Interface (UI)

In Information Technology the user interface (UI) is everything designed into an information device with which a person may interact. This can include display screens , keyboards , mouse and a appearance of the desktop. It is also the way through which a end user interacts with an designed application , web app or an mobile app. The growing dependence of many companies on web applications and mobile applications has led many companies to place increased priority on UI in an effort to improve the user's overall experience.

A. Identification module

In Identification module we have Ultrasonic sensors programmed using mongoose OS.Sensor measure the water level and sends the Data to Google pubsub[7] via the ESP8266 [3] attached with it.Each Sensor has its unique device Id which will be used to recognise the area from which the data belongs to.After Google pubsub data is sent to the Google BigQuery via DataFlow Created on the server.Dataflow is a pipeline which sends data from Pubsub to Bigquery (Data repository).Since there will be continuous data from various sensors we will have to store it identify the area hence we will have to store it in the Database

Server code is written in Nodejs(ExpressJs). Frontend access the server via AJAX API calls (routes in Express Js).

Figure 7.2 Identification module

B. Analysis

In Analysis we determine the Severity of the respective area. Data is fetched via API call and based upon the water level severity of the respective area is determined done on client side.Based upon the Analysis level of the severity is determined .There are three types of severity

Level 1 : Water level between 0 to 5 inches

Level 2 : Water level between 5 to 10 inches

Level 3 : Water level more than 15 inches

C. Prediction

In prediction Module severity of the coming days is determined in order to make Officials ready for the coming difficulties.Here IBM Watson machine learning platform is used to Deploy the ML model.In the Model we have Implemented Decision trees to predict the class label.The we used the AJAX API calls to accesses ML model to the server.After Predicting the Level for different areas ,On the web page it has been shown top severity areas for the coming days.

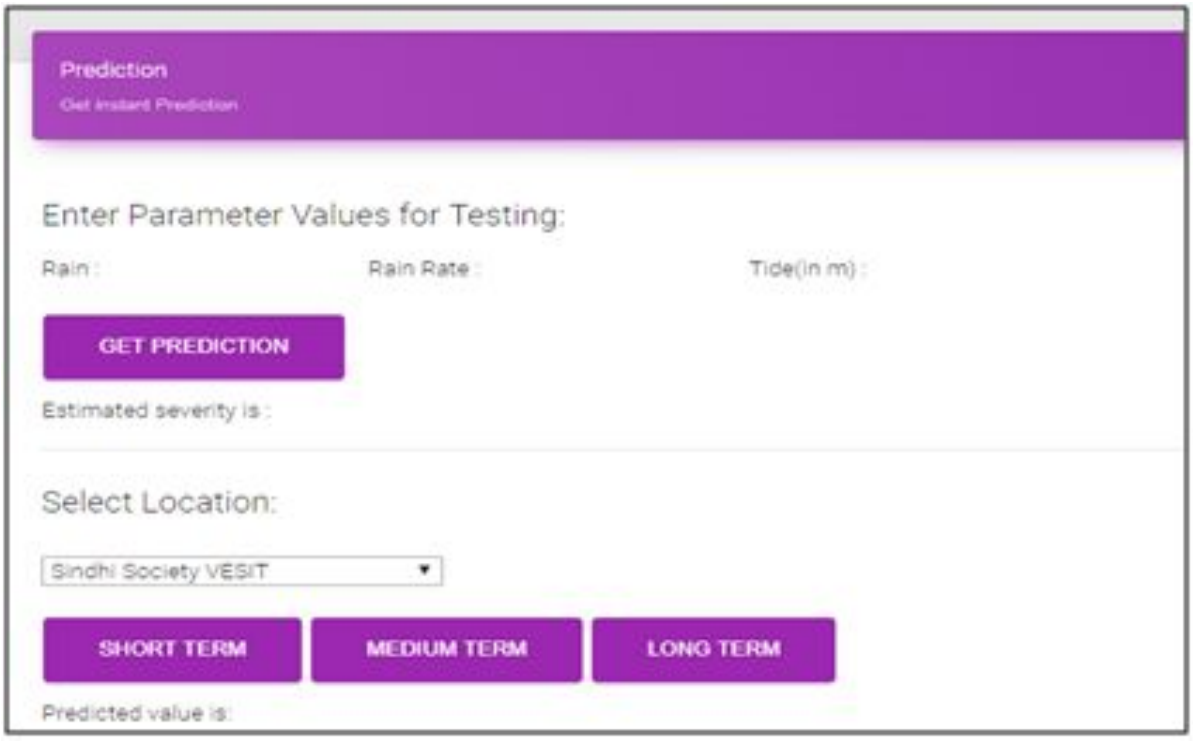


Figure 7.3 Prediction module

D. Notification

Since the main highlight for the System is to make officials get the knowledge about current situations at various places so we have used the Twilio API to automatically notify the user.It will send the current water level and time to the Official or the user of the respected user.Express framework is used to code the notification module.

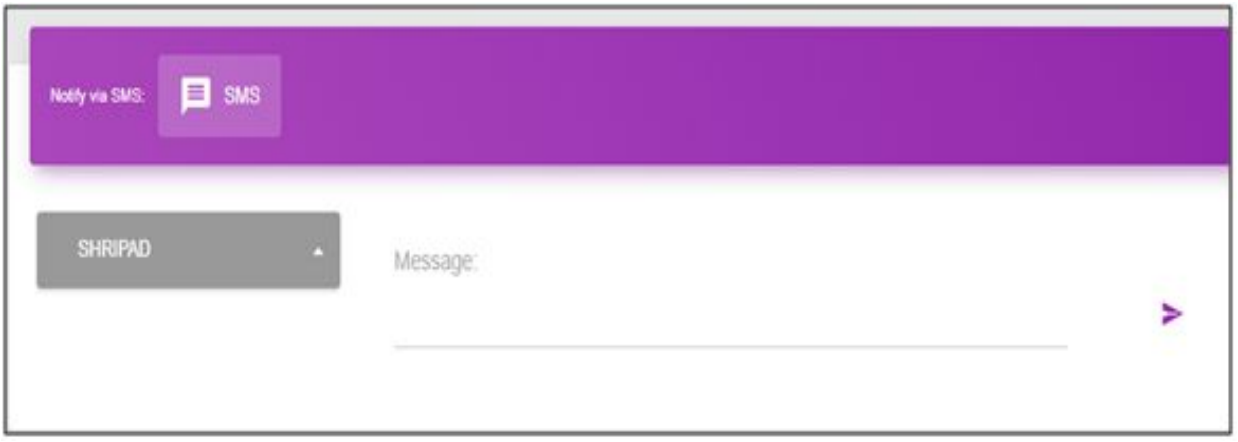


Figure 7.4 Notification module

E. FAQ Chatbot

For the new User to the system there is facility of the FAQ chatbot.It will give the answers to the basic queries and brief overview of the system.Google Dialog flow is used to design Chatbot to answer FAQin main website.Here the user will get the knowledge about the basic entities and directions to use the system.

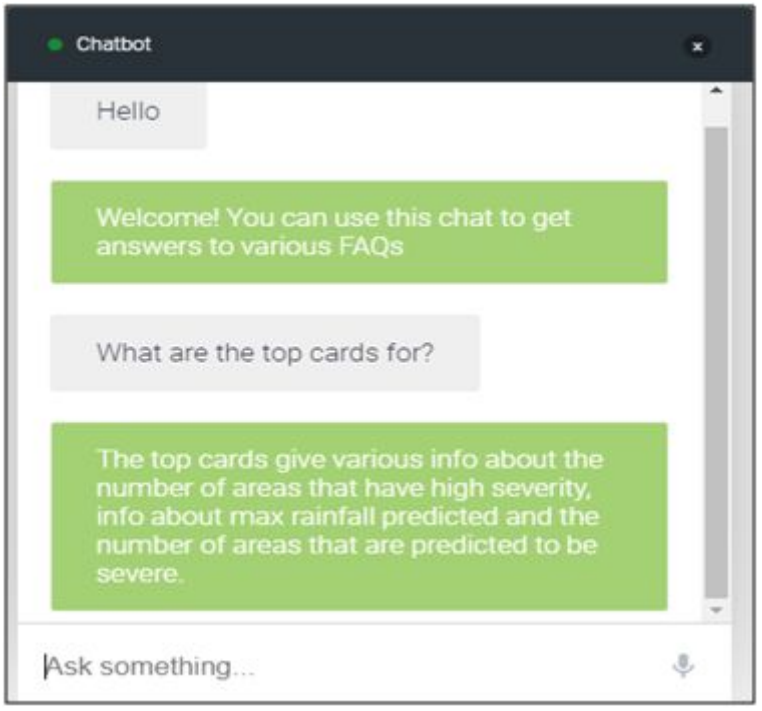


Figure 7.5 Chatbot on webpage

F. FB Chatbot

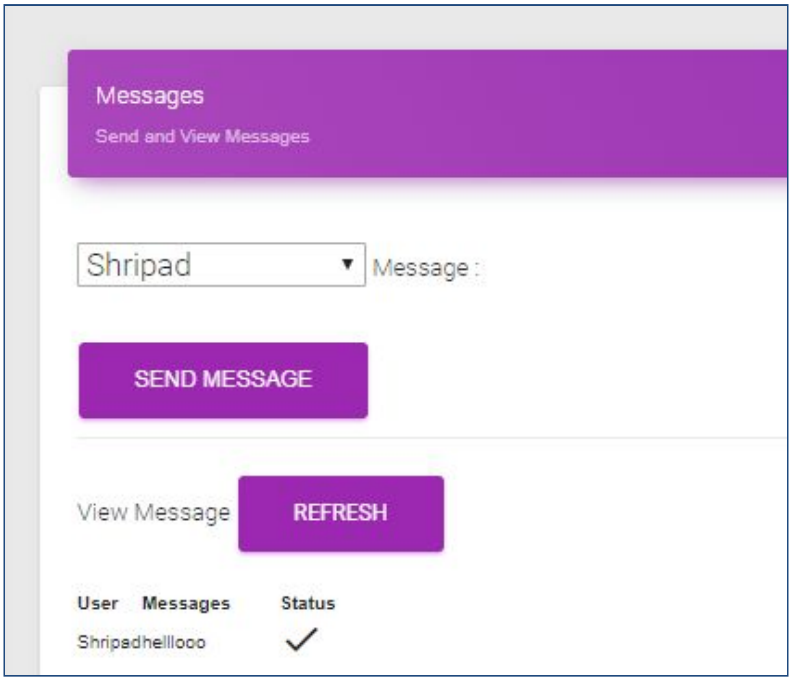
As it becomes harder for the officials to manage the phone calls during worst situations of the water logging so we have Introduces the FaceBook Chatbot form where anyone can report the waterlogging to the officials.Dialog flow and Google cloud functions is used to implement this bot.The reported messages will be shown on the Online Reporting Module in th web page.

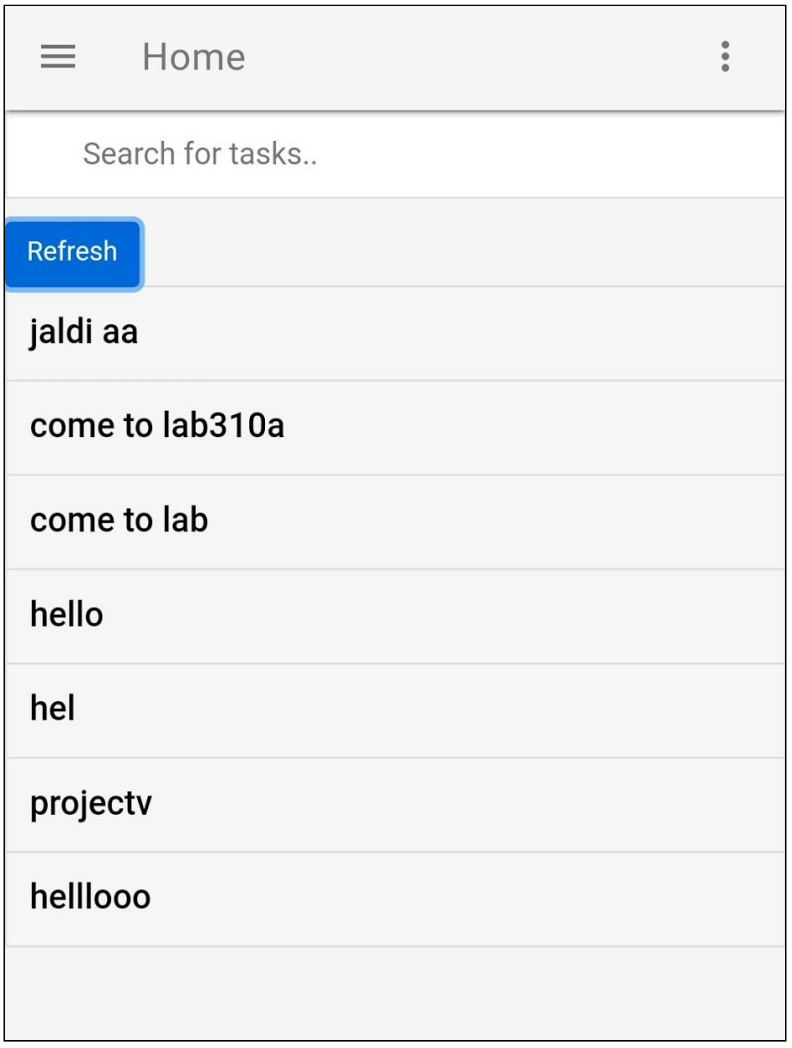
Client uses FB messenger to report logging near his location. FB messenger transfers this data to Diaglowflow.Dialog flow sends this data to a webhook (which is an API to enter data in Bigquery)Client fetches the reported logging via AJAX API calls to Bigquery to display the data.

Figure 7.6 FB chatbot

G. Task Check

Another requirement of BMC was that they needed to verify if the message sent by the official has been read by the subordinate or not. For this we thought of a whatsapp like app in which there is a single tick on delivery of message on the website and double tick on the receiver app when the receiver sees the message. This system can be further used for analysing the employee performance by calculating difference between message delivery and message reading. The lesser the difference the better the performance. Also this can be used for verification. The working is as shown under. The official wants to send message to Shripad, he/she selects the subordinate from the list, types the message in message area suppose:"hellllooo" and sends message. When the official clicks refresh button the table will be updated along with status (single tick). Now the subordinate opens the app and clicks refresh button, he/she will receive the message. Now when the official will click refresh button on the website, its status will be updated to double tick as that subordinate has read the message.


Messages
Send and View Messages
Shripad
Message :
SEND MESSAGE
View Message
REFRESH
User
Messages
Status
Shripadhelllooo


Home
Search for tasks..
Refresh
jaldi aa
come to lab310a
come to lab
hello
hel
projectv
helllooo

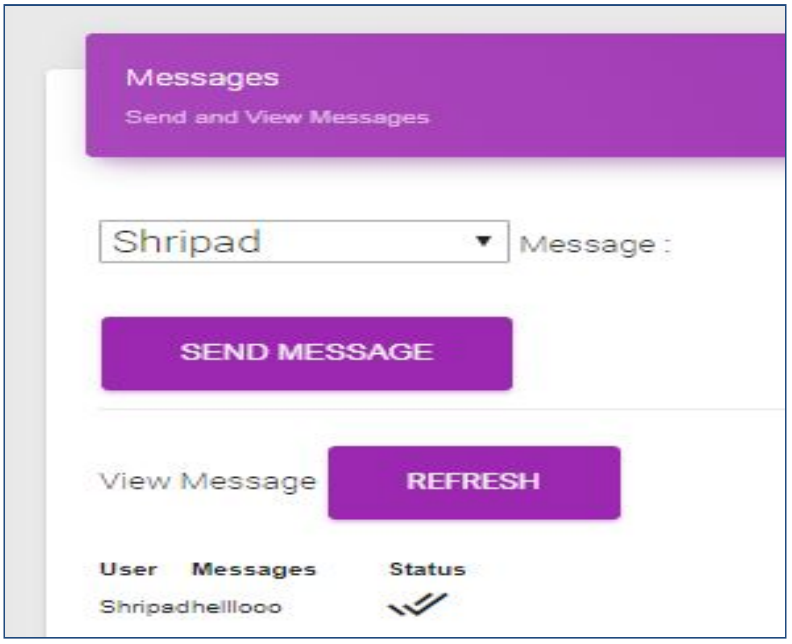


Figure 7.7 Task Check

7.4 Graphical Outputs

At the Reports Module the Region Wise Water logging reported in the different years has been shown. Google data studio is used to trousers charts and reports and the iframe is then inserted into the html web page.

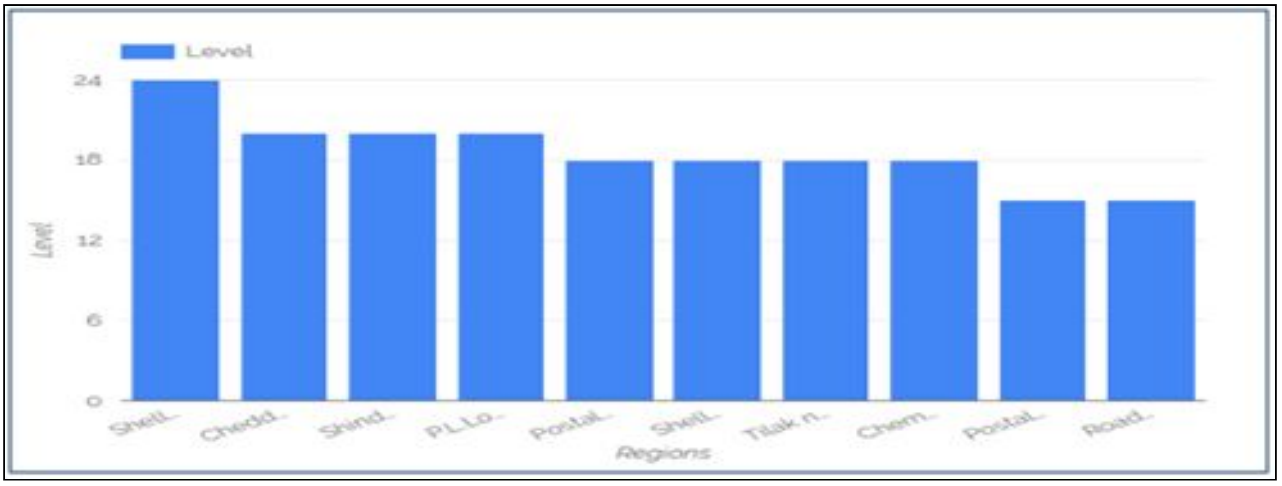


Figure 7.8 Max Rainfall in 2017

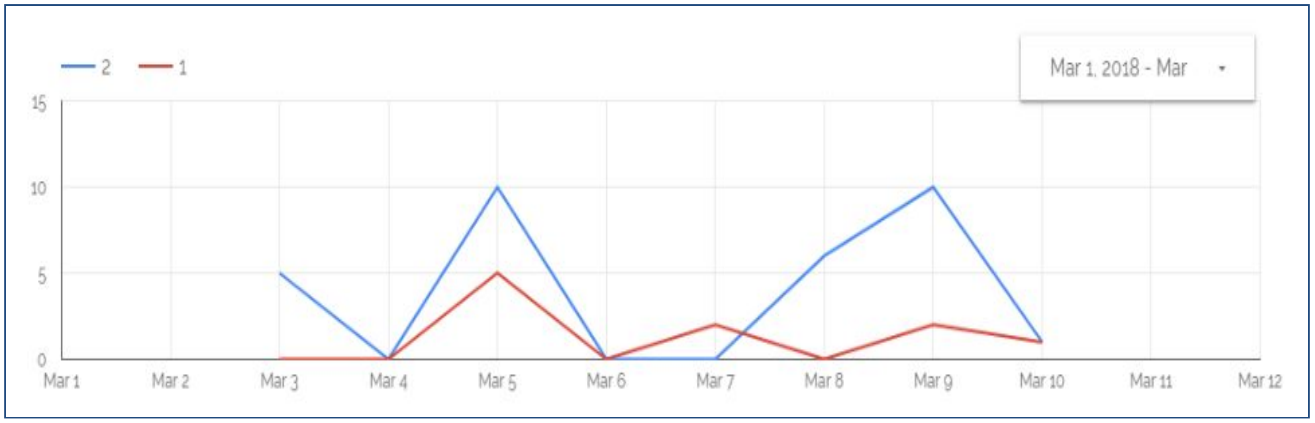


Figure 7.9 Water-level variation with respect to time

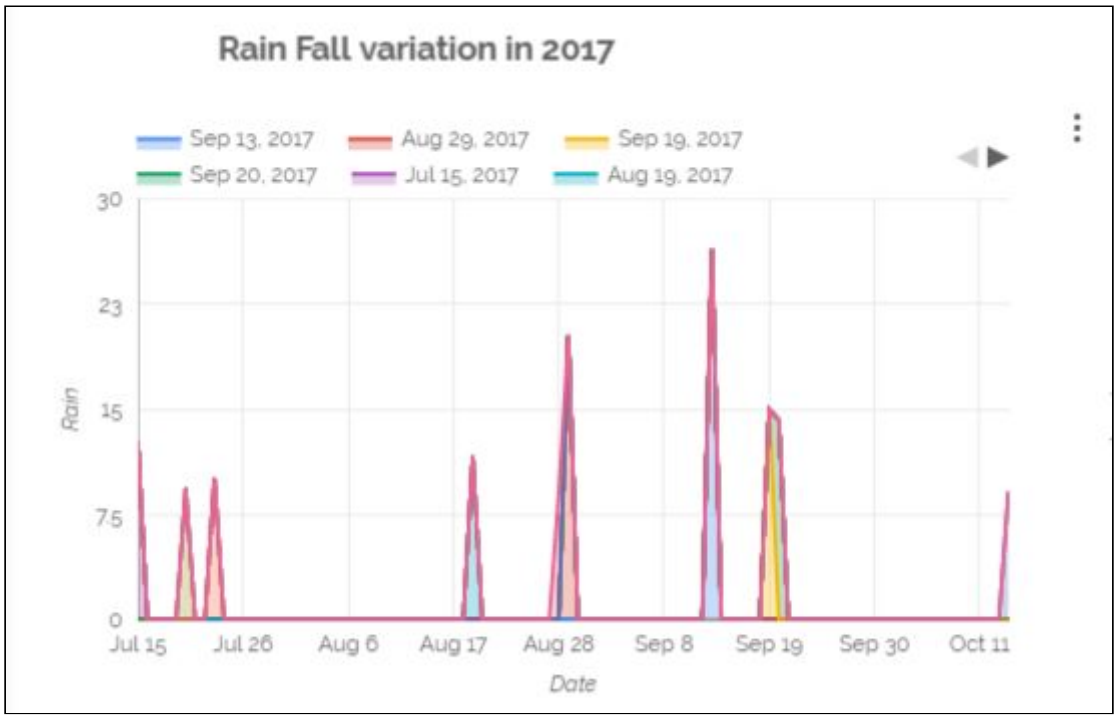


Figure 7.10 Rainfall Variation in 2017

7.5 Tables obtained

1.

Number of Messages reported Per Day in Different Areas

date	vv	ulhas	abcd	Vesit	Nagar	Mohan	Chembur	BMC
								location / level
2018-03-27	-	-	-	-	-	-	-	12
2018-03-21	-	-	-	2	-	-	1	-
2018-03-20	-	13	-	-	-	-	-	-
2018-03-14	12	-	-	-	-	-	-	-
2018-02-27	-	-	-	-	-	-	-	12
2018-02-26	-	-	10	12	-	2	-	-
2018-02-24	-	-	-	8	-	-	-	-
2018-02-23	-	-	-	-	10	-	-	-

Figure 7.11 Facebook reporting

This table shows the region wise number of complaints registered in that particular region for that particular date along with the severity specified by the people living in that area via Facebook chatbot.

2.

Online Reports

View reportings done by people via Facebook Chatbot

Location	Date	Level
Chembur	2018-03-21	1
Chembur	23-2-2018	5
ulhas	2018-03-20	13
Vesit	2018-03-21	2
Vesit	2018-02-26	12
Vesit	2018-02-24	8
Nagar	2018-02-23	10
Mohan	2018-02-26	2
abcd	2018-02-26	10
BMC	2018-03-27	12
BMC	2018-02-27	12
vv	2018-03-14	12

Figure 7.11 Online reporting

The above table shows onlines reports for the recorded severity in a particular area on that particular date via facebook chatbot.

3.

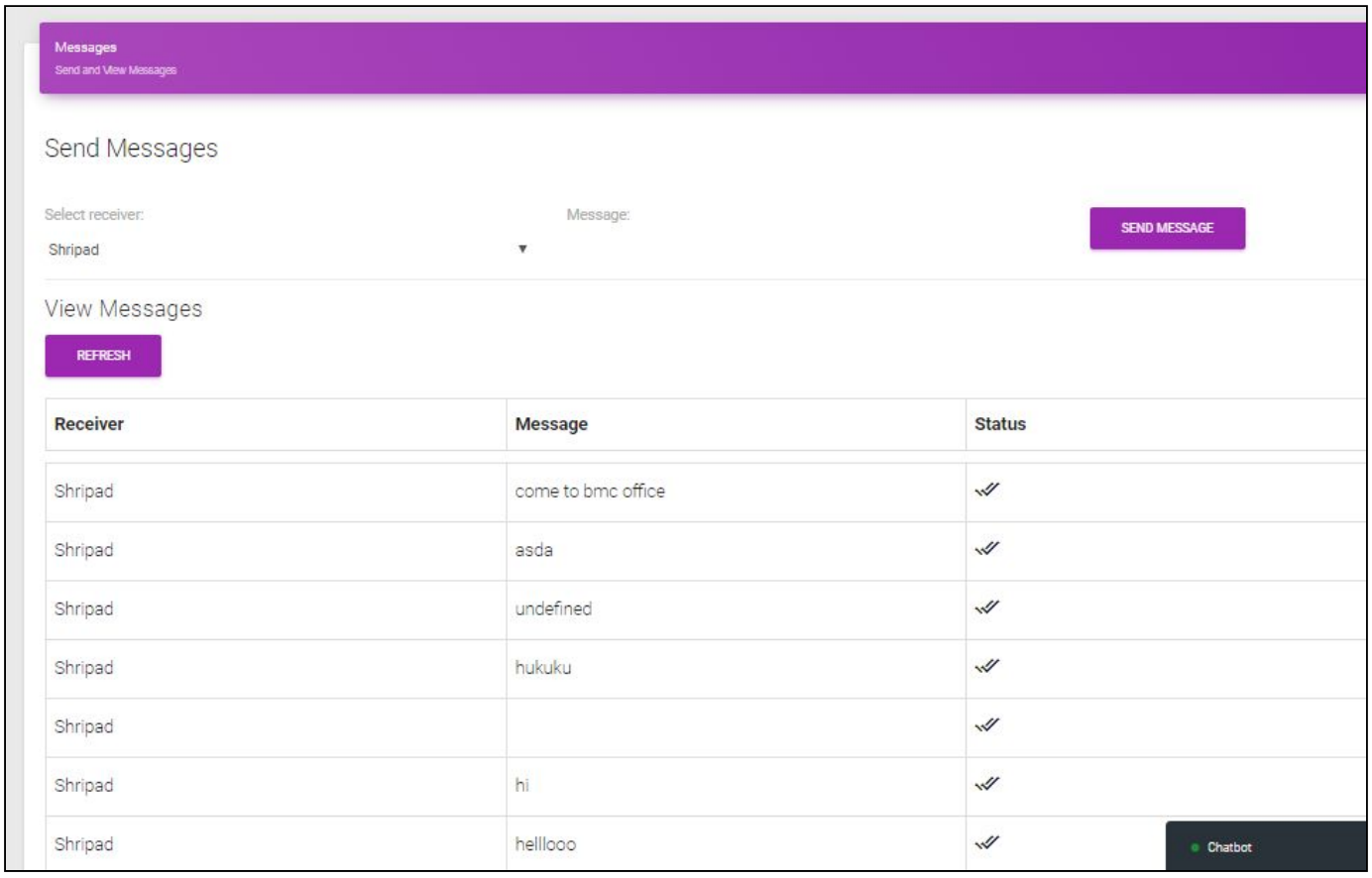


Figure 7.11 Messages

The above table shows the Task Management area. There is a single tick on delivery of message on the website and double tick on the receiver app when the receiver sees the message, the table above shows the records for the particular receiver along with the message and status.

Chapter 8
Conclusion

8.1 Limitations

- Each unit of sensor node costs about 500-600 rupees. So cost for deploying such a system can be a limitation.
- In the current system, common people cannot get the status of waterlogging by any means. However they can report waterlogging free of cost via Facebook Messenger.
- The current system cannot do analytics automatically on its own and requires human intervention.
- The prediction module has a recall score of about 95% and accuracy of 94% by using decision tree as the ML model.However, employing a more complex model can improve the accuracy and recall scores.

8.2 Conclusion

Waterlogging is one the most common natural disasters and have widespread effect. Waterlogging forecasting is hence an important research area, and several possible solutions have been proposed in literature. The current work uses the Internet of Things approach by collecting data from a wireless sensor network and using a machine learning model for predictions. Based on the current technologies available, using ZigBee for waterlogging identification is neither effective nor cost efficient.

In the proposed system Identification module will identify the waterlogging in particular area, from each area water level will be taken and then compared to the thresholds to determine the status of waterlogging as normal , low , medium and high.Inside analysis module severity of the waterlogging and Actions for that particular area will be given.

Inside prediction module based upon the current and past rainfall data , previous year prediction data value for water level will be predicted along with the comparisons with actual value afterwards to calculate error rate .Inside notification module based upon the current water level and severity authorities will be informed using SMS notifications , EMAIL notifications and push notifications.

8.3 Future Scope

Features such as getting live status of waterlogging using a chatbot or by dialing a Toll-free number can be done in order for the common people to understand the status of the work by BMC officers.

BMC officers face difficulty in assigning and managing tasks during a critical situation like waterlogging, so there’s a need to develop a task management module in the system.

The system can even be improved by adding a module that will automatically do data analysis and send detailed reports to the ward officer via email in a interval of say 1 -2 week.

Chapter 9

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Chapter 10
Appendix

10.1 List of Figures

10.2 List of Tables

10.3 Review Sheets:

1. Project review sheet I

Industry Proj. BMC Chembur

Project Evaluation Sheet 2017 - 18 GROUP NO: 8

Title of Project: Identification, Analysis and prediction of urban waterlogged areas

Group Members: Abhijeet Bhattacharyya (09), Shrinpad Laddha (38), Nitin pandey (52), Neeraj premani (56)

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg & Mgmt principles (3)	Life - long learning (3)	Professional Skills (5)	Innovative Approach (5)	Total Marks (50)
Review of Project Stage 1	5	4	4	2	4	2	1	2	2	3	3	3	5	5	45

Comments: Good work

Mrs. Anjali Yede
Name & Signature Reviewer1

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg & Mgmt principles (3)	Life - long learning (3)	Professional Skills (5)	Innovative Approach (5)	Total Marks (50)
Review of Project Stage 1	5	4	4	2	4	2	1	2	2	3	3	3	5	5	45

Comments:

Date: 26/02/2018

Name & Signature Reviewer2
Ms. Shwetha Reddy

Inhouse/ Industry:

Class: D17 A/B/C

Group No.: 8

Project Evaluation Sheet 2017 - 18

Title of Project: Identification, Analysis and Prediction of Urban Waterlogged areas

Group Members: Abhijeet Bhattacharya (09), Shaipad Laddha (38), Nikin Pandey (52), Neeraj Premani (56).

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg &Mgmt principles (3)	Life - long learning (3)	Professional Skills (5)	Innovative Approach (5)	Total Marks (50)
Review of Project Stage I	5	5	5	3	~~4~~	1	1	1	2	3	3	2	4	4	47

Comments: Product completed

~~Contact board with FAQ's~~

② APP User Login. Testing

P. Sweta Sweta

Name & Signature Reviewer1

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg &Mgmt principles (3)	Life - long learning (3)	Professional Skills (5)	Innovative Approach (5)	Total Marks (50)
Review of Project Stage I	5	5	4	2	4	1	1	1	2	3	3	2	4	4	46

Comments: Product is complete 100%.

Date: 15th March,2018

① App User Login

② Testing of product

Name & Signature Reviewer2

2018 3rd International Conference for Convergence in Technology (I2CT)

Identification, Analysis and Prediction of Urban Waterlogged Areas

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Abstract-

Waterlogging is one of the most recurrent calamity, causing remarkable damage to property and human live. Traditional approaches like mathematical model or hydrological models are inefficient in predicting waterlogging. Also there isn't a system to identify real-time waterlogging and institutions like BMC rely heavily on phone call and SMS to identify waterlogged areas.

This research paper proposes a system that identifies waterlogging in real time. Our proposed algorithm calculates severity and reports it to respective officials via SMS, push notification and Web application.

Index Terms- **Neural Network; WSN; prediction; Real-time identification**

I. INTRODUCTION

Urban-Waterlogging refers to the rainwater that gets accumulated and remains stagnant in a particular area and has no place to drain-off, which causes various problems. Waterlogged areas are a fairly well-known setbacks in almost all cities and villages accross India. Basically it is caused when inflow of water is much more than runoff. [1] Monsoon is a dominant and extended season in India. The south-west summer monsoon continues for a four-month-long period from June through September, followed by the northeast or retreating monsoon from October to December. The main cause of severe perpetuated waterlogging situation as shown in Fig. 1 is that the drainage system is commonly outdated, notably in the older parts of the metro cities and most of the non-metro cities. The current system to get rid of water-logging is based either on its passage through manholes on its own, or starting of some pumping stations which are switched on by operators on getting notice from officials. This system is highly dependent and inefficient also there's no provision for real-time identification of water-logging areas. Our system aims at identifying such waterlogged areas in real time and do a detailed analysis of it, notify the authorities about it and suggest ways to cope up with the situation. We also intend to predict the waterlogged areas.

Figure 1 : Waterlogging in an urban area

Causes of Waterlogging

- Improper drainage management

Drainage facilities are asymmetrically managed. Despite having the proper infrastructure and advanced pipelined network system, these are not regularly maintained which causes water-logging problems.

- Low terrain

Urban construction in low-lying terrain often become water-logged after rainfall, since the rainwater that gets accumulated cannot be dispensed.

- Change in underlying surface condition

The development of Urban areas and construction over there has caused reduction in the vegetation cover, which ultimately reduces the seepage. Urbanization causes modification in the surface material that leads to the crystallization of the bedding surface which further deteriorates the amount of surface runoff.

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Problems due to waterlogging

Water-logging affects the following areas in a severe manner:

- **Traffic Problems**

It causes a delay in routine of daily activities. Waterlogging in crowded areas can slow down the traffic movement.

- **Sanitation**

Water that gets accumulated for a very large period of time such as in low lying areas , can cause numerous health issues. Diseases such as malaria and dengue can spread and this can cause health diseases to people living in those areas

- **Delaying suburban railway system**

Water that gets accumulated on the railway tracks due to improper drainage management causes a delay in the routine of the railway system.

Lacuna in Existing system

- **CWC Flood Forecasting System**

Central Water Commission[2] is a leading Technical Organization of India which aces in the field of Water Resources and is presently employed as an attached institution of many departments that handle flooding problems across various states.

Limitations :

- Limited reach (only 221 stations).
- No real time identification of waterlogged areas.
- No system to measure severity of waterlogging .
- No live notifications to authorized officials.

- **Storm Water Management Model(SWMM)**

It is developed by the United States EPA in 1971 which is also called as SWMM which is used for the dynamic rainoff calculation since it's release it has gone some major and minor changes. SWMM is freely available software and it is released in public domain. Using SWMM model we can easily demonstrate water inflow and outflow in particular area or region.It provides integrated development environment for the study of single term or long term water runoff component.

SWMM is amongst one of the numerous hydrological transport prototypes which has been used by prominent agencies and through advisers and institutes throughout the planet. It consists of C engine code and also delphi code that can be easily imitated and transcribed by students.

Applications of SWMM EPA are as follows:

- Modelling of the segments of drainage system for surplus water control in specific region
- High-level planning of sewer collection systems
- 1 dimensional and 2 dimensional predictions of flood levels

Problems in this system are :-

- Not feasible for India
- Strictly based on Storm water runoff
- No real time Identification of Water logging areas

II. RELATED WORKS

The present-day approach for waterlogging prediction and identification generally involves a WSN model with some machine learning or statistical process for forecasting whereas the previous, non-WSN based approaches rely on phone call by native residents and SMS to identify waterlogged areas.

In [3], based upon hydrological and hydraulic conditions of pipe in research area the SWMM model is used. In [1], designed system predicts the waterlogging prone areas on various routes using GPS signal. Based upon the location detection and confidence score all the routes with the estimates are rendered in google map . In [4], a wireless sensor network which is established on the ZigBee specification which makes use of the IEEE 802.15.4 protocol. However, the range of each sensor node is between 10-100 m (line of sight). Due to cost of ZigBee chips, overall cost of implementation gradually increases. In [4], a robust linear regression model is used for the purpose of flood prediction. They have proposed different sensors in the Wireless Sensor Network such as rainfall, water discharge etc, but the prediction model can be applied to any number of parameters.

III. HARDWARE

The architecture consists of three main components

1. Sensor node:
   Consists of ultrasonic sensors (HC-SR04 Distance Measuring Transducer Sensor [5]) and ESP8266 module. Connects with central router using IEEE 802.11n standard (Wi-Fi).Sensor node can be installed at places like light poles (Plane of ultrasonic sensor has to be parallel to ground surface).

2. Central router:
   Collects data from sensor nodes and forwards it to the gateway router via ethernet.

3. Gateway :
   Receives data from multiple routers
   And forwards it to the Application
   server via the Internet.

This research uses a wireless sensor network based on Wi-Fi , which makes use of the IEEE 802.11n protocol. It principally operates on a 2.4 GHz radio frequency, with a

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data rate of 60 Mbps maximum, however 150-200 Mbps is more typical depending on channel frequency and number of antennas used. Since the constraints are low power and medium range, technologies such as cellular,BLE,Z-wave are ruled out. The physical range of each sensor node fluctuates between 40-50m.

Technologies such as Sigfox and LoRa which are low power,high range solutions, have not been implemented in India (when this paper was written).

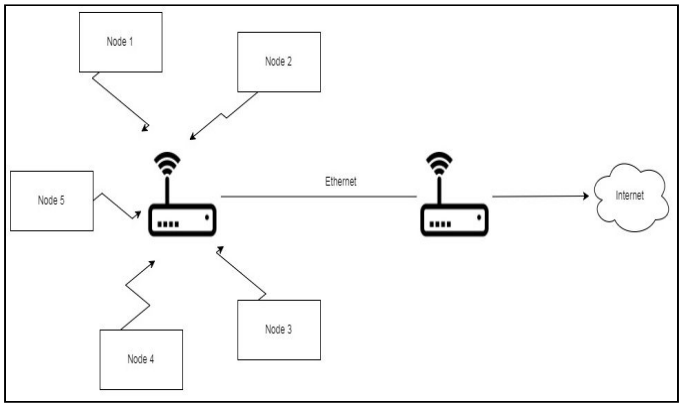

Figure 2 : WSN using star topology

IV. SOFTWARE

Our proposed system collects data in application server from sensors via internet in a regular interval of 5 min.

Once data is received the identification module identifies the water level and details about respective authorities for all areas.

Parameters like current water level measured by sensors, current precipitation amount and drainage cleaning status will be used to improve the efficiency of the system.

This data is transferred to the Analysis module,wherein score is calculated based on parameters like current water level,current precipitation amount,high tides and drainage status. This score is used to measure severity of waterlogging.

V. PREDICTION

For the prediction purpose specially for time series predictions Neural networks are one of the efficient methods.Neural networks works in similar fashion like human brains.They consists of various neurons at various levels.When a new Data comes it goes through each stage and various neurons.Contrast to neural networks conventional algorithms like Linear regression,k-nearest neighbours does not perform well in case of time-series examples.

Different activation functions such as ReLU, tanh, leaky ReLU, sigmoid are used in deep learning neural networks.

There are different types of Recurrent neural networks (RNN) and one of those is Long Short Term Memory (LSTM) networks can also be used for prediction.

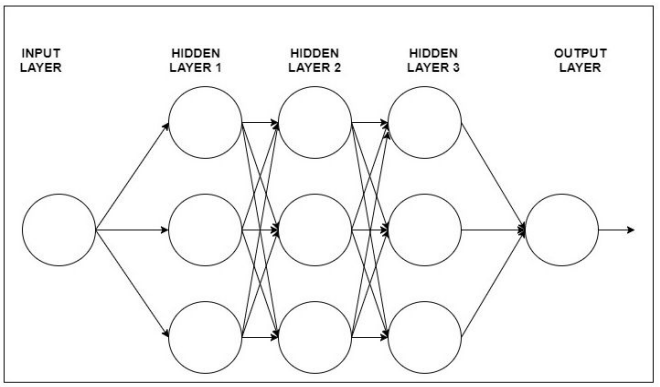

Figure 3: A sample deep neural network with 3 hidden layers.

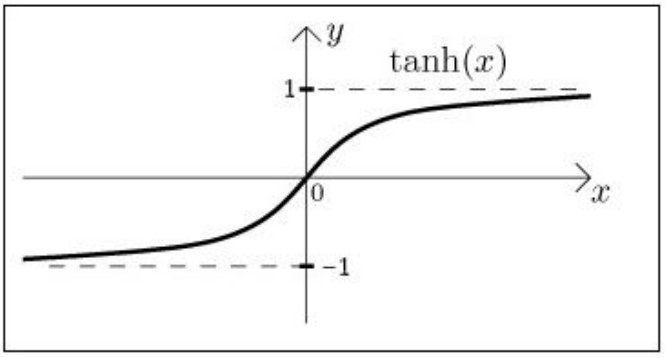

Figure 4: The tanh function used as activation function for neural network.

x: weighted sum of signals from previous layer in neural network

y: output of a node in neural net.

VI. METHODOLOGY

System is divided into multiples modules:

A. Identification

For Identification there are ultrasonic sensors [5] to determine water height,if the water height is above threshold then it will be divide in the several categories of normal,low,moderate,high and critical.

B. Prediction

In prediction module, a deep neural network takes inputs like current and previous rainfall data,previous prediction data ,current and past water level data system and calculates probability of waterlogging for all areas.

C. Analysis

Inside Analysis module using precursory waterlogging results and weather data score will be calculated.

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Algorithm 1 : Measure Score

```
1. procedure MEASURESCORE(area)
2.    for all subarea do
3.       wL ← current water level
4.       rF ← current Rainfall Data
5.       hT ← high tides
6.       dR ← Drainage
7.       score = α*wL + β*rF + γ*hT + δ*dR
8.                Thresholds[]{low , medium , high} =
.           getThresholds(subarea);
9.       if( score <  low) then status = 0
10.       if(low < score < medium ) then status = 1
11.       if(medium < score < high) then status = 2
12.       if(score > high) then status = 3
13.       Regions[i] = {subarea,status };
14.    end for loop
15.    return regions[];
16.end procedure
```

*current water level = height measured by sensors during normal condition - height measured by sensors during waterlogging.
*getThreshold(subarea) returns threshold value for a particular area 'subarea' depending on whether the area is low lying or not.

For all sub-areas based on four parameters a score will be calculated and based upon the score, status will be determined for each sub area. The immutable values are determined experimentally where
α : Water level constant
β: Rainfall data constant
γ: High tide constant
δ: Drainage constant

D. Notification
In Notification module authorities will be notified based upon the current water logging data and severity of waterlogging.There are three types of notifications sms notifications, email notifications and push notifications.

E. Evaluation and reports
In this module based upon error rate(from prediction module),severity,current and previous rainfall data Graphs and Reports will be generated.Graphs will be of three types

1. Year vs efficiency
2. Top 10 water prone areas
3. Weekly region wise reports.

VII. CONCLUSION

Waterlogging is one of the most usual water related natural disaster which have multiple adverse effects on human life.Hence prediction of waterlogged areas is one of the important aspect.The proposed system uses Internet of Things(IOT) approach for collection of water level from waterlogged prone areas and using Machine Learning model for the prediction of water level in a particular area. Based on the current technologies available, using ZigBee for waterlogging identification is neither effective nor cost efficient.
Hence we propose a system which is based on hardware of Wi-Fi (IEEE 802.11n standard) using star topology. Our approach associate the power of Neural Networks to process data given by the ultrasonic sensor network and make short,medium and long term predictions.

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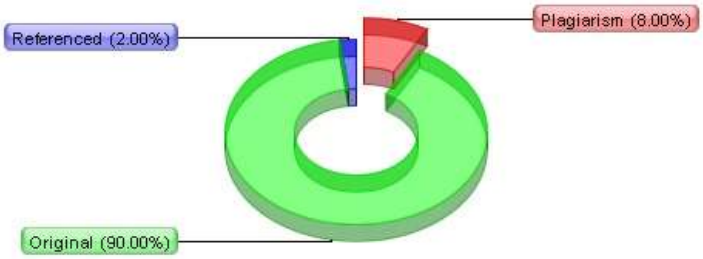

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Mumbai,INDIA Mumbai,INDIA Mumbai,INDIA Mumbai, INDIA /w:t /w:r w:r wmailto:gresha.bhatia@ves.ac.in gresha.bhatia@ves.ac.in /w:tabhijeet.bhattacharya@ves.ac.in shripad.laddha@ves.ac.in nitin.pandey@ves.ac.in /w:neeraj.premani@ves.ac.in Abstract:
Waterlogging is the most common disaster, causing significant damage to property and human live. Traditional approaches like mathematical model or hydrological models are inefficient in predicting waterlogging. Also there isn't a system to identify real-time waterlogging and institutions like BMC rely heavily on phone call and SMS to identify waterlogged areas.
This research paper proposes a system that identifies waterlogging in real time. Our proposed algorithm calculates severity and reports it to respective officials via SMS, push notification and Web application.
Keywords- Neural Network;WSN;prediction; Real-time identification
INTRODUCTION
Urban-Waterlogging refers to the rainwater that gets accumulated and remains stagnant in a particular area and has no place to drain-off, which causes various problems. Waterlogged streets are a fairly well-known setbacks in cities and villages throughout India. Basically it is caused when inflow of water is much more than runoff. [1]Monsoon is a dominant and extended season in India. The south-west summer monsoon continues for a four-month-long period from June through September, followed by the northeast or retreating monsoon from October to December. Drainage is often outdated, mainly in the older parts of the metro cities and most of the non-metro cities. This leads to severe perpetuated waterlogging situation as shown in Figure 1. The current system to get rid of water-logging is based either on its passage through manholes on its own, or starting of some pumping stations which are switched on by operators on getting notice from officials. This system is highly dependent and inefficient also there's no provision for real-time identification of waterlogging areas. Our system aims at identifying such waterlogged areas in real time and do a detailed analysis of it, notify the authorities about it and suggest ways to cope up with the situation. We also intend to predict the waterlogged areas. Figure 1 : Waterlogging in an urban area
Causes of Waterlogging
Improper drainage management
Drainage facilities are unevenly managed. Despite having the proper infrastructure and advanced pipelined network system, these are not regularly maintained which causes waterlogging problems. /w:t /w:
Low terrain
Urban construction in low-lying areas often become waterlogging areas after rainfall, since the rainwater that gets accumulated cannot be discharged in time due to the terrain. /w:t /w:r
Change in underlying surface condition
Urban development and construction has caused waterlogging problems. Urbanization decreases the natural vegetation, changes the surface material, and hardens the bedding surface, and reduces the amount of surface runoff. /w:t
Problems due to waterlogging
Waterlogging affects the following areas in a severe manner:
/w:
Traffic Problems It causes a delay in routine of daily activities. Waterlogging in crowded areas can slow down the traffic movement. /
/w:t
Sanitation Water that gets accumulated for a very long time such as in low lying areas , causes various health issues. Diseases such as malaria and dengue can spread and this can cause health diseases to people living in those areas
Delaying suburban railway system
Water that gets accumulated on the railway tracks due to improper drainage management causes a delay in the routine of the railway system. /w
Lacuna in Existing system
CWC Flood Forecasting System
Central Water Commission[2] is a premier Technical Organization of India within the field of Water Resources and is presently functioning as an attached workplace

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of the Ministry of Water Resources, River Development and Ganga

Rejuvenation, by the Government of India.Limitations :
Limited reach (only 221 stations).
No real time identification of waterlogged areas.
No system to measure severity of waterlogging .
No real time notifications to officials.
Storm Water Management Model(SWMM)
The

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United States Environmental Protection Agency (EPA

United States Environmental Protection Agency (EPA
) [2] Storm Water Management Model is a dynamic rainfall-runoff, subsurface-runoff
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simulation model used for single-event or
continuous simulation of surface/subsurface water quantity/quality from primary urban/suburban areas. SWMM is one of the
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hydrology transport models which the EPA and other agencies have applied broadly throughout North America and through consultants and universities throughout the
planet.
EPA SWMM is a
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public domain software that may be freely copied and distributed. It consists of C engine code and delphi
code that can be easily replicated and copied by students.
Applications of EPA SWMM include
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Designing and sizing of drainage system components for flood control
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Master planning of sewer collection systems

1D and 2D predictions of flood levels
Problems in this system are :-
Not feasible for India
Strictly based on Storm water runoff No real time Identification of Water logging areas
II. RELATED WORKS
The modern approach for waterlogging prediction and identification usually involves WSN model with some statistical or machine learning process for forecasting. Older, non-WSN based approaches rely on phone call by native residents and SMS to identify waterlogged areas.
In [3], based upon hydraulic and hydrological conditions of pipe in research area SWMM model is used. In [1], designed system predicts the waterlogging prone areas on various routes using GPS signal.Based upon the location detection and confidence score all the routes with the estimates are rendered in google map . In [4], a wireless sensor network based on the ZigBee specification which makes use of the IEEE 802.15.4 protocol is used. However, the range of each sensor node is between 10-100 m (line of sight). Due to cost of ZigBee chips, overall cost of implementation gradually increases. In [4], robust linear regression model is used for flood prediction. They propose different sensors in the WSN such as water discharge, rainfall etc., but the prediction model can be applied to any number of parameters.
III. HARDWAREThe architecture consists of three main components
Sensor node:
Consists of ultrasonic sensors and ESP8266 module. Connects with central router using IEEE 802.11n standard (Wi-F
i)Central router:
Collects data from sensor nodes and forwards it to the gateway router via /w:t /w:r
ethernet. /w:t /w:r
Gateway :
Receives data from multiple routers /w:t /w:r
And forwards it to the Application /w:t /w:r
server via the Internet. /w:t /w:r
This research uses a wireless sensor network based on Wi-Fi , which makes use of the IEEE 802.11n protocol. It mainly operates on a 2.4 GHz radio frequency, with a data rate of 60 Mbps maximum, however 150-200 Mbps is more typical depending on channel frequency and number of antennas used.Since the constraints are low power and medium range, technologies such as cellular,BLE,Z-wave are ruled out. The physical range of each sensor node varies between 40-50m.
Technologies such as Sigfox and LoRa which are low power,high range solutions, have not been implemented in India (when this paper was written).
Figure 2 : WSN using star topology /w
IV. SOFTWARE
Our proposed system collects data in application server from sensors via internet in a regular interval of 5 min. Once data is received the identification module identifies the water level and details about respective authorities for all areas.
This data is transferred to the Analysis module,wherein score is calculated based on parameters like current water level,current precipitation amount,high tides and drainage status. This score is used to measure severity of waterlogging.
/w:t /w:r w:r V. PREDICTION
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Neural networks are a set of algorithms [4], modeled loosely after the human brain, that are designed to recognize patterns. They interpret sensory data through a kind of machine perception, labeling or clustering raw input. The patterns they recognize are numerical, contained in vectors, into which all real-world data, be it images, sound, text or time series, must be translated.
Deep learning
is the name we use for

is the name we use for

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"stacked neural networks"

; that is, networks composed of several layers.
Different activation functions like sigmoid,tanh,ReLU,leaky ReLU are used in deep learning neural networks.
Figure 3: A sample deep neural network with 3 hidden layers.
Figure 4: The tanh function used as activation function for neural network.
x: weighted sum of signals from previous layer in neural network
y: output of a node in neural net.
VI
. METHODOLOGYSystem is divided into multiples modules:
A. IdentificationFor Identification there are ultrasonic sensors to determine water height,if the water height is above threshold then it will be divide in the several categories of normal,low,moderate,high and critical.
B. Prediction
In prediction module, a deep neural network takes inputs like current and previous rainfall data,previous prediction data ,current and past water level data system and calculates probability of waterlogging for all areas.
C. Analysis
Inside Analysis module using precursory waterlogging results and weather data score will be calculated
.Algorithm 1
: Measure Score1. procedure MEASURESCORE(area)
2. for all subarea do
3. wL ← current water level4. /w:t /rF ← current Rainfall Data5. /w:t /hT ← high tides6. /w:t /dR ← Drainage7. /w:t /score = α*wL + β*rF + γ*hT + δ*dR8.
Thresholds[]{low , medium , high} = . getThresholds(subarea); /w:t /9. if(score low) then status = 0
10. if(low score medium) then status = 1
11. if(medium score high) then status = 2
12. if(score high) then status = 3
13. Regions[i] = {subarea,status };
14. end for
15. return regions[];
16.end procedure

For all subareas based on four parameters a score will be calculated and based upon the score status will be determined for each sub areas.The constants are determined experimentally where α : Water level constant β: Rainfall data constant
γ: High tide constant
δ: Drainage constantD. Notification In Notification module authorities will be notified based upon the current water logging data and severity of waterlogging.There are three types of notifications sms notifications, email notifications and push notifications.
E. Evaluation and reports
In this module based upon error rate(from prediction module),severity,current and previous rainfall data Graphs and Reports will be generated.Graphs will be of three types Year vs efficiency
Top 10 water prone areas
Weekly region wise reports.
VII. CONCLUSION
Waterlogging is one the most common natural disasters and have widespread effect. Waterlogging forecasting is hence an important research area, and several possible solutions have been proposed in literature. The current work uses the Internet of Things approach by collecting data from a wireless sensor network and using a machine learning model for predictions. Based on the current technologies available, using ZigBee for waterlogging identification is neither effective nor cost efficient.
Hence we propose a system based on Wi-Fi (IEEE 802.11n standard) using star topology. Our approach combines the power of deep neural networks to process data provided by the sensor network and make short,medium and long term predictions.
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3]Simulation of Rainstorm Waterlogging Based on SWMM and Visualization Module Research

-Wenting Zhang1,3 , Xiang Wang2, Yongzhi Liu 4,Tao Zhang5 (China)
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Identification of Urban Waterlogged Areas along with its Prediction

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Abstract*: *Waterlogging is a natural phenomenon where water gets accumulated in an area which results to damage and destruction of material things which causes setback in our day to day lives. We are proposing a system that uses a set of hardware and Google Cloud Platform in such a way that it identifies water logging problem in a particular area. The Web Application displays different areas with various severity colour codes. It also does the analysis based on previous year reports and does predictions of waterlogging severity. The prediction of waterlogging is done using machine learning algorithm where a target variable helps us to determine the score of waterlogging in a particular area. In order to simplify the work of BMC officials we have developed a notification module along with Facebook chatbot which will simplify the identification of waterlogged areas for them.

Keywords: Waterlogging, Decision tree, Google Cloud Platform, IoT, prediction.

I. INTRODUCTION

Now as we are aware of what is waterlogging which that mainly occurs by rainwater gets accumulated in a particular area and what are the problems associated with it we will deal with how to cope up with this problem and steps to mitigate it[1]. One of the major cause of waterlogging is the improper maintenance of drainage system which results to sanitary and heavy traffic problems. Some of the other causes of waterlogging includes the high tides ,which mainly cunts if the area is closer the coastline, area's height etc. The studied region for this paper is chembur. Currently the system in action to get rid of it quiet simple and based on the severity in the region and phone calls from native peoples. Until now the disposal of this surplus water was purely based on its own passage through manholes which is very unreliable as they can get choked anytime, so have come with a solution to deal with this problem, to identify the waterlogged area we will be placing ultrasonic sensors[2] and esp8266 (microcontroller with wifi modules)[3] on the street lamps as they are at a safe height. Also they will have continuous source of electricity.

These sensors will collect the change in height levels data, continuously within time intervals of 15 minutes(variable) and send the data to server. Here the data is stored in database and analyzed for severity and various reports generation.

The responsible authority is informed about the water-logging condition through push notification. He/She can then remotely give command to start the pumps or inform the drainage cleaning groups to clear out the sewers of that area. Furthermore this data of the previous years are collected and is analyzed for predictions in long terms, medium term and short term. The accuracy of predictions is cross-checked by comparing it with actual value and predicted value.

II. NEED OF THE PROJECT

In the last couple of years there has been a need of a system that not only identifies waterlogging but also predicts it. It has been observed that waterlogging during the rainy season has caused more number of live damages, also material damages to our society. So it is a high time to build such a system that helps the BMC officials to act fast in cases of waterlogging, so that no human live or material damages are caused.

Thereby, we propose a system where we actually track each and every area for changes in the water level and based on that we classify them as low, medium and high. This helps in notifying the BMC officials about the current level and the quick action they need to perform based on that severity.

Also when the water logging occurs, there are multiple people trying to report, hence creating a chaos therefore the area goes unreported many a times, so we have developed Facebook chatbot where a user can report waterlogged area anytime, anywhere without any delay.

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III. DATA USED

For the prediction Module, data is collected from various sources like local Authorities , Online Websites , Weather APIs [4] and Tide APIs [5]. The Data mainly contains the Rainfall Data of the particular area , Tides Schedule for the nearest coastline area and rain rate of the area. The Data collected is used to put input inside the prediction Module, where Decision Tree Algorithm is used to predict the Label for Input Data. For the future prediction of the value the data will be collected from Online APIs, which will provide the forecasted data for coming 10 - 15 days.

IV. METHODOLOGY

The main methodology of the system is to collect the data from the different sensors which are installed at various locations will provide the current water level at respective location. Based upon the current water level at the location the marking is shown on the website. The system uses different APIs in order to get current rainfall and tides schedule.
System is divided into multiples modules:

A. Identification Module

In order to identify different regions based on the waterlogging level, each region comprises of ultrasonic sensors to determine the height at any given time. Based on the height level measurement regions can be classified into low, medium and high categories.

B. Prediction Module

For the prediction module we have used the Decision tree for the classification of the area into predefined categories .There are three predefined categories {0 , 1 , 2} where 0 represents the low level severity , 1 represents the medium level severity and 2 represents the High level severity.

C. Analysis Module

In Analysis Module data obtained from the sensors is put into use, where the actual severity score of each region is calculated. This also helps in notifying the BMC officials.

D. Notification Module

In Notification module authorities will be notified based upon the current water logging data and severity of waterlogging. There are three types of notifications sms notifications, email notifications and push notifications.
Using the twilio service as cloud communication platform, authorities will be notified about the different regions and their water logging le

E. Evaluation and reports Module

In this module based upon error rate(from prediction module),severity, current and previous rainfall data Graphs and Reports will be generated. Graphs will be of three types

1) Year vs efficiency
2) Top 10 water prone areas
3) Weekly region wise reports.

V. IMPLEMENTATION

For the Implementation of the above methodology in which we have used Ultrasonic Sensor [2](HC-SR04 Distance Measuring Transducer module) to measure the current water level at the particular level. At the server end we have used Google Cloud Platform to host the server , maintain the hardware devices , Database in Big Query[6].

A. Identification Module

In Identification module we have Ultrasonic sensors programmed using mongoose OS. Sensor measure the water level and sends the Data to Google pubsub[7] via the ESP8266 [3] attached with it. Each Sensor has its unique device Id which will be used to recognise the area from which the data belongs to. After Google pubsub data is sent to the Google BigQuery via Data Flow Created on the server. Dataflow is a pipeline which sends data from Pubsub to Bigquery (Data repository).Since there will be continuous data from various sensors we will have to store it identify the area hence we will have to store it in the Database
Server code is written in Nodejs (ExpressJs). Frontend access the server via AJAX API calls (routes in Express Js).

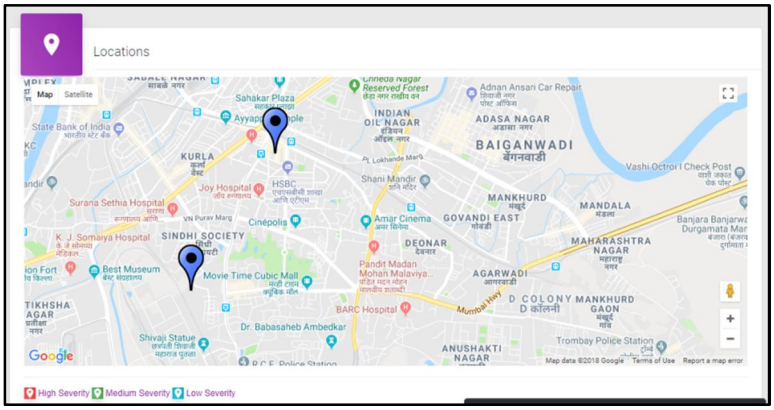

Fig. 1 Identification module

B. Analysis

In Analysis we determine the Severity of the respective area. Data is fetched via API call and based upon the water level severity of the respective area is determined done on client side. Based upon the Analysis level of the severity is determined .There are three types of severity

Level 1 : Water level between 0 to 5 inches

Level 2 : Water level between 5 to 10 inches

Level 3 : Water level more than 15 inches

C. Prediction

In prediction Module severity of the coming days is determined in order to make Officials ready for the coming difficulties. Here IBM Watson machine learning platform is used to Deploy the ML model. In the Model we have Implemented Decision trees to predict the class label. The we used the AJAX API calls to accesses ML model to the server. After Predicting the Level for different areas ,On the web page it has been shown top severity areas for the coming days.

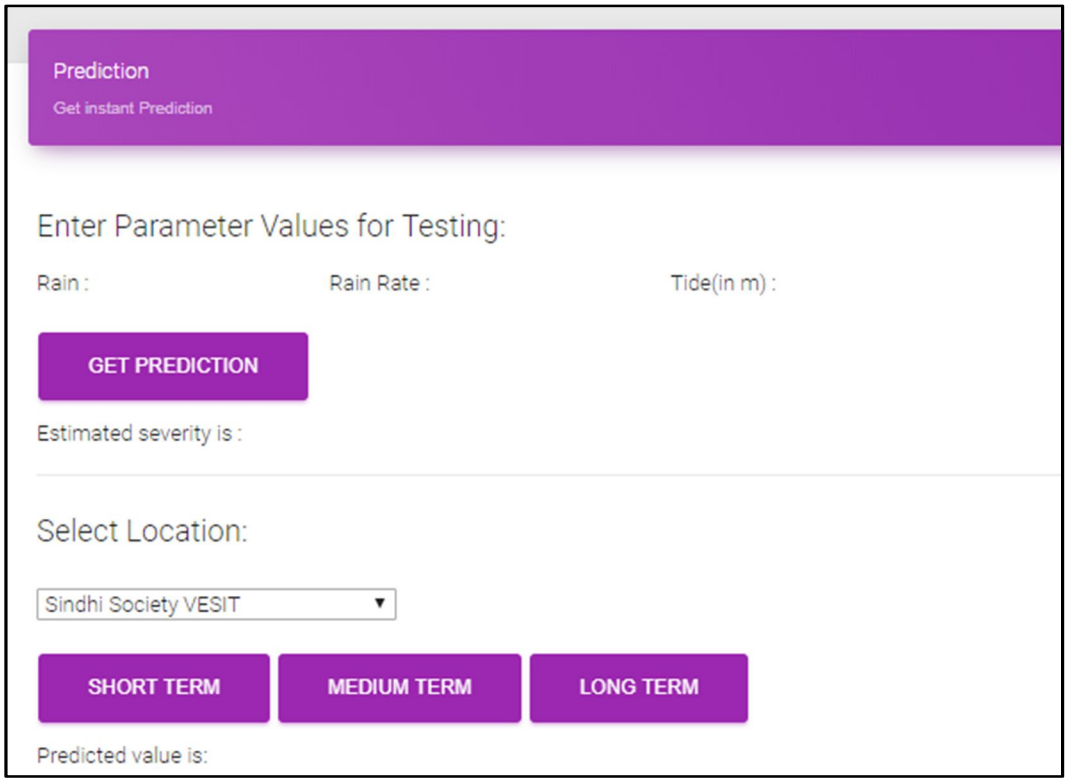

Fig. 2 Prediction module

D. Notification

Since the main highlight for the System is to make officials get the knowledge about current situations at various places so we have used the Twilio API to automatically notify the user.It will send the current water level and time to the Official or the user of the respected user. Express framework is used to code the notification module.

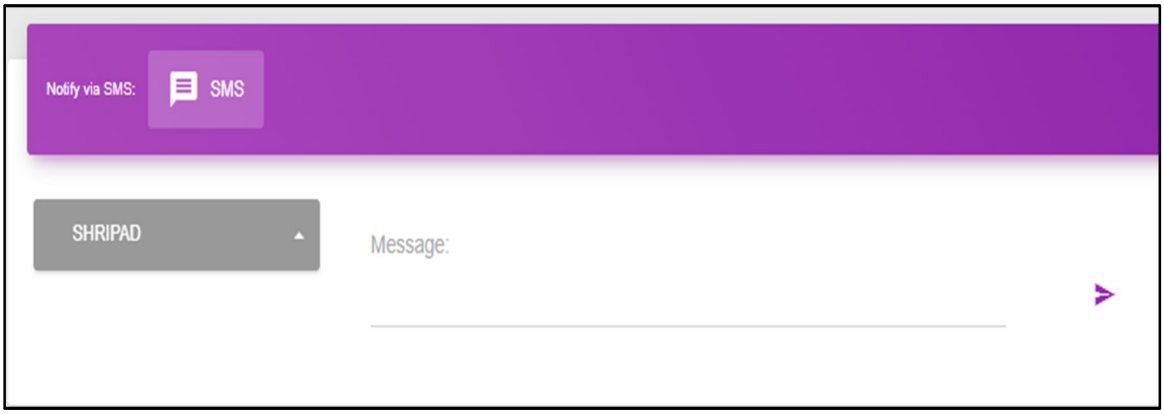

Fig. 3 Notification module

E. FAQ Chatbot

For the new User to the system there is facility of the FAQ chatbot. It will give the answers to the basic queries and brief overview of the system. Google Dialog flow is used to design Chatbot to answer FAQin main website. Here the user will get the knowledge about the basic entities and directions to use the system.

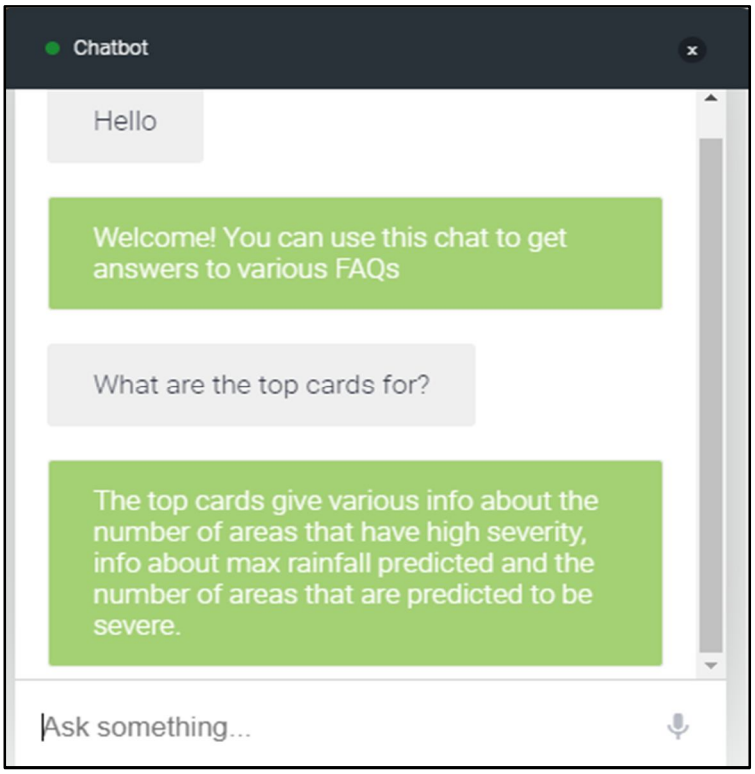

Fig. 4 Chatbot on webpage

F. FB Chatbot

As it becomes harder for the officials to manage the phone calls during worst situations of the water logging so we have Introduces the FaceBook Chatbot form where anyone can report the waterlogging to the officials. Dialog flow and Google cloud functions is used to implement this bot. The reported messages will be shown on the Online Reporting Module in th web page.

Client uses FB messenger to report logging near his location. FB messenger transfers this data to Diaglow flow. Dialog flow sends this data to a webhook (which is an API to enter data in Bigquery)Client fetches the reported logging via AJAX API calls to Bigquery to display the data.

Fig. 5 FB chatbot

G. Reports

At the Reports Module the Region Wise Water logging reported in the different years has been shown. Google data studio is used to trousers charts and reports and the iframe is then inserted into the html web page.

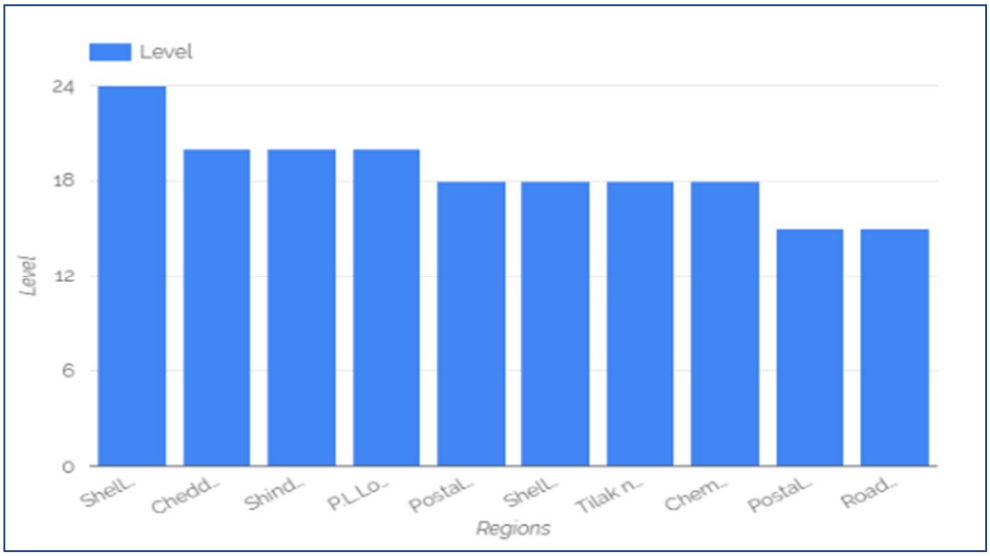

Fig. 6: Max Rainfall in 2017

H. Maps

To Identify the particular area easily Google maps has been used. To show it User is required to enter info like (Name of officer, latitude, longitude. Phone number) in the Add Sector module .Client uses the latitude, longitude of the installed sensors to report Waterlogging on map using Google maps API.

Colour codes are used to indicate severity (Blue - low level, Green - medium level , Red - high level) on maps.

V. RESULTS

For testing purpose we have installed two hardware modules at different places , based upon the water level it is updating the indicator in the webpage as follows:

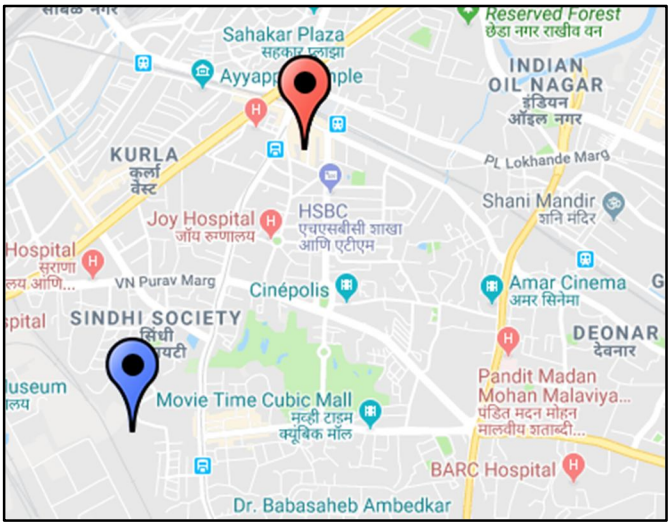

Fig. 7 Severity Identification in two different areas

As we can see that the indicator in collectors colony region is blue which means that the waterlogging severity in that region is low but the severity on the other region which is near the chembur station is colored red which means that the waterlogging severity in that particular region is high. For the Machine Learning we have used the Decision tree model the tree structure of the model is as follows.

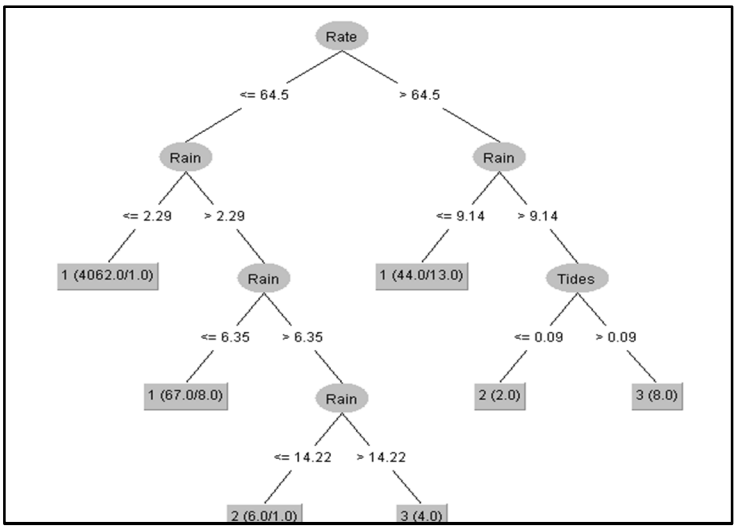

Fig. 8 Decision tree

The above decision tree is generated using the tool weka, as it is clear that the root node is Rain rate based upon which the tree gets splitted into two parts. Since it is an multi level classification so we have some parameter repeated more than one time

VII. CONCLUSION

The waterlogging is a natural cause mainly occurs due to high rainfall but there are certain other factors like High tides(if an area is near to the coastline) , area's height does matter upto an extent. The proposed system Identifies the waterlogging in particular area using the sensors data. For the prediction of waterlogging in future it uses previous available data and creates an decision tree model. For the communication with the server we can use other technologies like Zigbee but those are not efficient as the proposed one. Based upon the parameters it can make short term, medium term and long term prediction for coming days. Since the backend of the system is handled by google cloud platform non-functional requirements like load on server, backend security are taken care of indirectly.

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Identification of Urban Waterlogged Areas along with its Prediction Dr. Mrs. Gresha S Bhatia Abhijeet Bhattacharya Shripad Laddha Nitin Pandey Neeraj Premani Deputy HOD , CMPN Computer Engg. Computer Engg. Computer Engg. Computer Engg. V.E.S.I.T V.E.S.I.T V.E.S.I.T V.E.S.I.T V.E.S.I.T Mumbai,INDIA Mumbai,INDIA Mumbai,INDIA Mumbai,INDIA Mumbai, INDIA gresha.bhatia@ves.ac.in abhijeet.bhattacharya@ves.ac.in shripad.laddha@ves.ac.in nitin.pandey@ves.ac.in neeraj.premani@ves.ac.in

Abstract - Waterlogging is a natural phenomenon where water gets accumulated in an area which results to damage and destruction of material things which causes setback in our day to day lives.

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The prediction of waterlogging is done using machine learning algorithm where a target variable helps us to determine the score of waterlogging in a particular area. In order to simplify the work of BMC officials we have developed a notification module along with Facebook chatbot which will simplify the identification of waterlogged areas for them.

Index Terms - Waterlogging , Decision tree,Google Cloud Platform, IoT, prediction I - Introduction Now as we are aware of what is waterlogging which that mainly occurs by rainwater gets accumulated in a particular area and what are the problems associated with it we will deal with how to cope up with this problem and steps to mitigate it[1]. One of the major cause of waterlogging is the improper maintenance of drainage system which results to sanitary and heavy traffic problems.

Some of the other causes of waterlogging includes the high tides ,which mainly cunts if the area is closer the coastline , area's height etc.The studied region for this paper is chembur.Currently the system in action to get rid of it quiet simple and based on the severity in the region and phone calls from native peoples.Until now the disposal of this surplus water was purely based on its own passage through manholes which is very unreliable as they can get choked anytime, so have come with a solution to deal with this problem, to identify the waterlogged area we will be placing ultrasonic sensors [2] and esp8266 (microcontroller with wifi modules) [3] on the street lamps as they are at a safe height. Also they will have continuous source of electricity.

These sensors will collect the change in height levels data, continuously within time intervals of 15 minutes(variable) and send the data to server. Here the data is stored in database and analyzed for severity and various reports generation. The responsible authority is informed about the water-logging condition through push notification.

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II - Need of the Project In the last couple of years there has been a need of a system that not only identifies waterlogging but also predicts it. It has been observed that

waterlogging during the rainy season has caused more number of live damages, also material damages to our society. So it is a high time to build such a system that helps the BMC officials to act fast in cases of waterlogging, so that no human live or material damages are caused.

Thereby, we propose a system where we actually track each and every area for changes in the water level and based on that we classify them as low, medium and high. This helps in notifying the BMC officials about the current level and the quick action they need to perform based on that severity. Also when the water logging occurs, there are multiple people trying to report, hence creating a chaos therefore the area goes unreported many a times, so we have developed Facebook chatbot where a user can report waterlogged area anytime, anywhere without any delay.

III - Data used
For the prediction Module, data is collected from various sources like local Authorities , Online Websites , Weather APIs [4] and Tide APIs [5].The Data mainly contains the Rainfall Data of the particular area , Tides Schedule for the nearest coastline area and rain rate of the area.The Data collected is used to put input inside the prediction Module , where Decision Tree Algorithm is used to predict the Label for Input Data.For the future prediction of the value the data will be collected from Online APIs , which will provide the forecasted data for coming 10 - 15 days.

IV - Methodology The main methodology of the system is to collect the data from the Different Sensors which are installed at various locations will provide the current water level at respective location.Based upon the current water level at the location the marking is shown on the website.The System uses different APIs in order to get current rainfall and Tides schedule. System is divided into multiples modules: A.

Identification Module In order to identify different regions based on the waterlogging level, each region comprises of ultrasonic sensors to determine the height at any given time. Based on the height level measurement regions can be classified into low, medium and high categories. B. Prediction Module For the prediction module we have used the Decision tree for the classification of the area into predefined categories .There are three predefined categories {0 , 1 , 2} where 0 represents the low level severity , 1 represents the medium level severity and 2 represents the High level severity.

C. Analysis Module In Analysis Module data obtained from the sensors is put into use,where the actual severity score of each region is calculated. This also helps in notifying the BMC officials. Algorithm 1 : Identification 1. procedure Identify_level(area) 2. for all sectors in area do 3. cWL ? get water level from sensor 4. cRF ? get current rainfall status from weather API 5. thr ? rainfall threshold 6. if(cWL > 0) then 7. if(cRF > thr) then 8.

if(cWL > 15) then output= high 9. else if(cWL<15 & cWL>5) then output=medium 10. else output= low 11. else output = false reading 12. else output = no waterlogging 13. end of the for loop 14. return output[] 15. End D. Notification Module In Notification module authorities will be notified based upon the current water logging data and severity of waterlogging.There are three types of notifications sms notifications, email notifications and push notifications.

Using the twilio service as cloud communication platform, authorities will be notified about the different regions and their water logging level with the severity E. Evaluation and reports Module In this module based upon error rate(from prediction module),severity,current and previous rainfall data Graphs and Reports will be generated.Graphs will be of three types Year vs efficiency Top 10 water prone areas Weekly region wise reports.

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Prediction In prediction Module severity of the coming days is determined in order to make Officials ready for the coming difficulties.Here IBM Watson machine learning platform is used to Deploy the ML model.In the Model we have Implemented Decision trees to predict the class label.The we used the AJAX API calls to accesses ML model to the server.After Predicting the Level for different areas ,On the web page it has been shown top severity areas for the coming days. / Figure 2 : Prediction module 4.

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make short term , medium term and long term prediction for coming days.Since the backend of the system is handled by google cloud platform non-functional requirements like load on server , backend security are taken care of indirectly.

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