

QUANTITATIVE ANALYSIS ON RAINFALL AND FLOOD MANAGEMENT

Submitted in partial fulfillment of the requirement for the award of
Bachelor of Engineering Degree of Civil Engineering

by

NAVEEN.S.K (37200047)

ROHITRAM . R (37200062)



**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT
SATHYABAMA**

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

JEPPIAR NAGER, RAJIV GANDHI SALAI, CHENNAI – 600119

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NAAC JEPPIAAR NAGAR, RAJIV
GANDHI SALAI, 600 119

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DEPARTMENT OF CIVIL ENGINEERING

BONAFIDECERTIFICATE

This is to certify that this Project Report is the bonafide work of NAVEEN.S.K (37200047) and ROHITRAM.R (37200062) who carried out the project entitled
“QUANTITATIVE ANALYSIS ON RAINFALL AND FLOOD MANAGEMENT
”under my supervision from December 2020 to April 2021.

Internal Guide
(Dr. S NANDHA KUMAR)

Head of the Department

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

We NAVEEN.S.K (37200047) and ROHITRAM.R (37200062) hereby declare that the Project Report “**QUANTITATIVE ANALYSIS ON RAINFALL AND FLOOD MANAGEMENT** ” done by us under the guidance of Dr.S. NANDHA KUMAR is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

DATE:

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SIGNATURE OF THE CANDIDATES

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ABSTRACT

Water Flood has been considered together of the foremost recurring and frequent disaster within the planet . because of recurrent prevalence, the economic loss and life damage caused by the flood has put more burden on economy than the opposite natural disaster. India also has continuously suffered by many flood events which claimed huge loss of life and economy. it has been found that incidences of flood are increasing very rapidly. Causes are often global climate change , cloud bursting, tsunami or poor river management, silting etc. With reference to the above data, we chose the topic quantitative qualitative analysis of Rainfall and Flood Management for the analysis we also collected the next data's namely rainfall data, temperature data, surface runoff, we also collected and studied the next maps flood inundation, geomorphological, land use / cover and slope maps. We studied and analyzed the above mentioned data which we discovered the Rajakilpakkam lake and Madambakkam lakes are low laying area. We simulated our idea of interlinking and channeling the water from one lake to a special through underground sewers with the help of computer aided softwares

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

A flood is an overflow of water on normally dry ground. this is often most ordinarily thanks to an overflowing river, a dam break, snowmelt, or heavy rainfall. Less commonly happening are tsunamis, storm surge. the foremost deadly arrive Chennai was in 2015 and killed between 500 - 1,000 people.

Floods have large social consequences for communities and individuals. As most of the people are well aware, the immediate impacts of flooding include loss of human life, damage to property, destruction of crops, loss of livestock, and deterioration of health conditions due to waterborne diseases. The discharge of 29,000 cusecs of water from Chembarambakkam Lake for 21 hours including heavy rainfall and surplus water in upstream tanks and catchments caused an enormous disaster for Chennai. The state lacked a law on Flood Plain Zone and an updated Water Policy to guard natural disaster

Enormous building build on the flood plains reduced the river capacity which made the Rivers that are unable to accommodate excess rain water overflow their banks onto neighbouring flood plains

1.2 PROLOGUE OF CHENNAI

Chennai, capital of Tamil Nadu lies within the Eastern Coast of South India where three watercourses meanders through it namely, Cooum River, Adyar River and Buckingham Canal. Chennai is that the fourth largest Metropolitan in India having a complete population of nearly 47 Lakhs¹ with a rate of growth of 13% and density of 26903. Within a century, Chennai has grown 8 fold times in population

1.3 Growth of Chennai City

Chennai, having a clear terrain is bounded by Bay of Bengal within the East with a mean elevation 6.7m from the mean water level . Chennai experiences most of its rainfall during October to December related to Depressions & frequent cyclones during this era . Average annual rainfall is about 1200 mm – 1300 mm being situated on the coastal side. City is drained by those 2 rivers additionally to several major & minor drainage channels through Buckingham Canal to Sea (Figure 2). the town is additionally having quite 50 Temple tanks additionally to natural water bodies to capture flood water and acts as spring water recharging wells.Chennai also has Pallikaranai swamps, Madhavaram&Manalijheels, Adyar&Couum Estuaries as a wetland sources aside from natural & manmade waterbodies.

1.4 Causes of Chennai Floods

Chennai frequently experiences flooding thanks to heavy rain related to depressions & cyclones. Of which few catastrophic floods during 1976, 1985, 1996, 1998, 2005, 2008 and 2010 caused heavy damages. Now-adays, unexpected holidays thanks to heavy downpour are quite common especially during October – December. In short, Chennai isn't starving for rain; it's starving for water which is thanks to mismanagement of water storage. In 2010, Chennai received about 760mm rainfall only during October – December period. Recent highest rainfall during a day was 423 mm on 27.10.2005. of these shows whether Chennai is ready to empty this flash flood without having hindrances in their day – today life? Closing of faculties thanks to flooding per annum is common in many parts of Chennai. Since it's more frequent per annum why effective management isn't so happened

TABLE 1 :- CAUSES OF CHENNAI FLOOD

CAUSES	TYPES OF FACTORS	ELEMENTS
Direct factors	Increase in rainfall	Due to global climatic changes
	Urbanization	Encroachment of all water bodies
		Construction of transportation networks all among the major water courses
		Increase in concrete spaces which stops percolation of water into the ground
		Decrease in open area/green spaces
		Lack of transportation facilities (esp. in slums)
	Topography	Plain terrain lacking natural gradient for free run off
Indirect factors	Inadequate & poor drainage systems	Sewage systems were planned originally before 4 decades and only few minor modifications made which is far below the requirement capacity
		Heavy siltation all along the drainage channel
		Lack of coordination between the agencies
	Disposal of solid waste & other debris	Attitude of people
		Lack of management measures by the agencies
	Vehicle parking on roads	Increase in concrete spaces

The city gets most of its seasonal rainfall from the north–east monsoon winds during mid of October to mid of December. Cyclones in the Bay of Bengal also sometimes hit the city

1.5 URBANIZATION

Chennai with the fast pace of developments has witnessed a gentle deterioration and reduce within the number of water bodies. it's estimated that quite half the wetlands are converted for other uses. Chennai had about 6502 small and large water bodies in and round the city, but today the amount has been reduced to but 30. Ownership of water bodies is scattered among various government departments and is that the root cause for lack of proper management. The Protection of Tanks and Eviction of Encroachment Act, came into effect from October 2007. However, there has been lack of implementation of this law. This 65-year old map (Figure 4) shows the locations of several water bodies. the grey areas of the map represent eris, or small ponds. the grey water bodies are seasonal, therein they seem during the rainy seasons and remain dry during the remainder of the year. When this map is compared with the recent one, it shows many of the water bodies have either shrunk or disappeared. consistent with records of the Water Resources Department (WRD), the world of 19 major lakes has been shrunk from a complete of 1,130 hectares to just about 645 hectares and hence reduced their storage capacity. Also, the bottom water level decreased up to 10m within 5 years (1995 – 2001)

The drastic change in Land Use of Chennai[6] thanks to urbanization (1995 – 2007) also adds fuel to the present risk of arrive per annum . The change in land cover during 1997 to 2001 is given in Figure 5. Most of the green cover are reduced to non-vegetative or a concrete space. thanks to this, the surface run-off is just too high and therefore the infiltration capacity of land has gone down drastically. thanks to the rise in impervious areas, Chennai experiences severity of floods during every heavy rainfall

1.6 Topography

Chennai features a terrain slope varying from 1:5000 to 1: 10000. it's a low-lying area and almost sort of a pancake. It rises slightly because the distance from the sea-shore increases but the typical elevation of the town isn't quite 22' above MSL,

while most of the localities are just at sea-level and drainage in such areas remains a significant problem.

1.7 Solid Waste Disposal & Vehicle Parking on Roads

The highest per capita solid waste generation in India is in Chennai (0.6kg/day)³. Majority of solid wastes are dumped during a mixed form in low lying areas & in open areas by Chennai Corporation. Even though there's a correct system of collection, segregation & disposal of wastes, it's a significant environmental concern which has got to be addressed separately. Chennai witnesses 425 new vehicles placed on road a day causing pressure for motorable and parking lot. Increase in impervious increasing the flood severity and later drought to follow. Increase in road space is accounting to only 3- 4% when comparing with the developed cities like London (20-25%)

1.8 Land use and land cover

Land use and land cover are terms frequently used interchangeably. However, these terms have significantly different meanings and applications. Land cover refers to physical features on the surface of the world vegetation, water, the built-up land. Whereas, land use specifically refers to the human (economic) utility of what's on the Earth's surface the study of land use/land cover (LU/LC) changes is extremely important to possess proper planning and utilization of natural resources and their management.

Traditional methods for gathering demographic data, censuses, and analysis of environmental samples aren't adequate for multi complex environmental studies, since many problems often presented in environmental issues and great complexity of handling the multidisciplinary data set; we require new technologies like satellite remote sensing and Geographical Information Systems (GISs). These technologies provide data to review and monitor the dynamics of natural resources for environmental management.

Remote sensing techniques are often wont to map and monitor changes in land use and land cover locally and over large expanses and to guage impacts of those

changes. Remote sensing techniques involve collecting data from a distance, then analyzing and interpreting collected data for specific purposes. during this chapter, remote sensing refers to collection and analysis of data using aerial photography and/or satellite imagery for the aim of monitoring the Earth's surface. With the capacity to remotely sense the Earth's surface, the science of land use/land cover mapping has gained the power to guage large areas at economical costs. Land cover/land use is one among the important parameters in calculating rainfall-runoff. It gives the individual area calculation of every sort of land. This calculation is employed find the curve number.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

The main purpose of literature survey is to offer a thought about the research and knowledge of the research conducted thorough , this forms the bottom on which one can perform the work and techniques which will be used for locating runoff. the subsequent literature survey described the research studied made on estimating rainfall runoff using SCS-CN method

2.2 LITERATURE SURVEY

Pallavi Saxena et al in 2010, made a study of groundwater recharge process in reference to climatic and geographical conditions in two states. They found that the overexploitation within the capital Delhi has reduced the water level depth by a substantial amount within the last 5 years and artificial methods to recharge the groundwater are often wont to supplement our water resources. they need explained the general efficiency of the methods wont to artificially recharge groundwater. Concluded that the simplest and simplest plus cost-effective technique is direct recharge of groundwater which further includes ditch & furrow method, percolation tanks and recharge of dug wells or hand pumps. additionally , case histories of two of the states also are discussed to elucidate the sort of techniques used there and supply sustainability to groundwater development.

Geetha.G in 2011 done a real-world case study in Chennai for 32 years of monthly mean data with meteorological parameters. This paper presents a replacement approach using a man-made Neural Network technique to enhance rainfall forecast performance and so as to forecast rainfall in Chennai City, Back Propagation Neural Networks (BPNNs), a knowledge driven technique supported the working rule of biological neurons are applied during this study. The mean monthly rainfall is predic by using ANN model. The model can perform well both in

training and independent periods. Their objectives are to differentiate what sorts of atmospheric situation can trigger rainfall, and determine what proportion rainfall are often generated in such situations. they need concluded that the synthetic neural networks (ANN) produces significant forecast yield in Chennai.

Magnus U Igboekive & Adindu Ruth both in 2011 studied Artificial recharge of water level through infiltration process using water from dams' lakes, rivers, runoff & rainfall. In Umudike a bit like many other areas, the speed of natural recharge is less than pumping rate and over exploitation of ground-water may be a threat to the water quality and table and creates hydrological imbalance Results of water level survey conducted at Umudike show that it peaks at 85 m (above sea level) before recharge and 95 m after recharge. The recharge of groundwater is essentially through rainfall and river water. The conclusion is Groundwater recharge may be a function of the annual average rainfall, hydrological characteristics, geology of the world , slopes, and nature of the soil. Increase in rainfall results in increase in water table . Conversely, decrease in rainfall results in groundwater depletion. Over exploitation within the sort of excessive pumping to satisfy the increasing water demands was observed within the study area. The geology of Umudike supports to an inexpensive extent, the natural infiltration process especially during the season . Artificial recharge yields good promising results when applied.

Sethuram.S in 2014 studied about the water issues & poor water security in Chennai as of 2012/2013. The aims of this paper were to explain water security, policy changes and to analyse the policies and adaptation strategies. The paper uses mixed- method and accidental sampling for data collection. the info show that, even with 700mm and 1100mm of annual rainfall, Chennai still has water insecurity. And he concludes that supported his investigation, the subsequent conclusions indicate the condition of water management in Chennai (as of 2012/ 2013): Poor water security. Results suggest that water system is irregular, unreliable and inadequate. this is often thanks to accessibility issues in certain areas. Contamination is mid to high thanks to domestic and other wastes and, hence the water-borne disease spread during summer. Open sewers impact

increase contamination in three regions out of 5 (regions of study). Demand management is lacking because the major project focus of policies is on supply improvement. While Rainwater harvesting does exist, the present demand management programs\ are insufficient to support Chennai's increase , management through conservation and efficiency needs further enhancement and dynamic action. Chennai needs enhanced control of project management and planning

Debu Mukherjee in 2016 made a study on Enhancing the groundwater resources in various parts of India & choice of recharge methods. This paper is about artificial groundwater recharge and it's a process of induced replenishment of the bottom water reservoir by human activities. it's the planned, act of augmenting the quantity of spring water available through works designed to extend the natural replenishment or percolation of surface water into the groundwater aquifers, leading to a corresponding increase within the amount of groundwater available for abstraction. The conclusion is that artificial recharge of spring water should be licensed and controlled by competent authorities consistent with specific requirements laid down in an appropriate permit system that ought to be flexible to adapt to site-specific conditions. The question of ground-water exploitation should be clarified on a case-by-case basis, taking under consideration all relevant aspects, including ecological ones

Subramani.T et al in 2017 made a study on the upkeep of water system and examined patterns of water sources supply & access to consumers. Through this study he found that Rapid urbanization throughout the planet results in pressure on infrastructure development for planners. during this Various technical investigation essential for planning water resources development activities for Chennai Metropolitan Area are indicated. this may function the start line for the long-term development of water management policies for this area. The conclusion is Reservoir operation forms a really important a part of the design and management of water resources. the discharge from a reservoir, at any time, depends on the prevailing demands, the available water within the reservoir, information about the

likely inflow within the reservoir and certain demands of the remaining a part of the water year. An operating policy is developed to guide the operators at the reservoir site choose about the discharge at any time. Huge amount of efforts has already been made towards the event of water resources management, but thanks to the complexity and difficulty in using those models within the real time situations, an easy model has been developed through this work.

Dr. A. S. kanagalakshmi et al in 2017 conducted a study to make opportunity for creating add storage tanks & to use the reservoirs water within Chennai Metropolitan area suitably. during this study Various technical investigations essential for planning water resources development activities for Chennai Metropolitan Area are indicated and this may function the start line for the long- term development of water management policies for this area. This study concludes that the prolonged dry weather and inadequate rains have led to the drop by the water level . Residents of several years are heavily hooked in to tanker lorry supply because the water level in their wells has dipped and also turned saline in some pockets like Okkiyam Thoraippakam and Ambattur. The remedial measures may include the treatment of sewage water without getting mixed with underground water and from edible water. The cleaning of the river coovum and Adyar are going to be effective measure to scale back the scarcity. The installation of the many desalination plants also reduces the water scarcity. Treating and reusing of non-toilet waste water from the building will surely be an efficient way because the water requirement for the building would to reduced

Ramsundram.N & Nisha khanam in 2018 made a modelling of hydrological cycle to simulate the water resources. They made a search for quite a decade on modelling of hydrological cycle to simulate the water resource and developed a modelling framework that predicts the reservoir inflow considering the longer term climatic scenarios. From this study their conclusion are as follows - The influence of climate parameters within the complex hydrological cycle plays a serious role in water resource development. The case study on reservoir inflow forecasting considering climate parameter, we observed that there's influence of climate parameter

on the inflow received by the reservoir.

Khan Mohammad Takal et al in 2017 studied about the estimation of the reservoir storage capacity & maximum potential head for hydro-power generation. Their objective is to estimate reservoir storage capacity and maximum potential head for hydro-power generation of the proposed Gizab multipurpose dam site within the Upper-Helmand basin, Afghanistan. is to estimate reservoir storage capacity and maximum potential head for hydro-power generation of the proposed Gizab multipurpose dam site within the Upper-Helmand basin, Afghanistan. Conclusion are as follows: The reservoir capacity is that the most vital aspect for hydrologic design. The reservoir capacity is design for mean monthly inflow data of several years using Mass Curve method and therefore the storage capacity is 1114.3 Mm³.

Eric Muala et al in 2014 conducted a study on estimation of discharge from Roseries reservoir and Nasser lake (Egypt) using satellite altimetry and imagery with the limited data available. This paper presents the feasibility of estimating discharges from Roseries Reservoir (Sudan) for the amount from 2002 to 2010 and Aswan High Dam/Lake Nasser (Egypt) for the periods 1999–2002 and 2005–2009 using satellite altimetry and imagery with limited in place data. during this study discharges were computed using the water balance of the reservoirs. Rainfall and evaporation data were obtained from property right data sources. this study evaluated the feasibility and accuracy of using satellite altimetry and imagery data to estimate stored water volumes and, combined with limited in place data, discharges from Roseries Reservoir (Sudan) and Lake Nasser (Egypt) within the Nile Basin. These estimated discharges wouldn't only provide information on water releases to downstream users, but also give insight into the reservoir operation strategies.

Biswadeep Bharali in 2015, his Objective is to estimate the reservoir runoff in Dibang Multipurpose Dam. Residual Mass curve is employed in determining the reservoir storage capacity. Advantages of using residual mass curve in state of using reservoir mass curve is additionally presented during this paper. within the present paper, reservoir capacity for the various year's monthly variation flow

have been computed by using residual mass curve. Residual mass curve saves the extra space needed for plotting a continuously rising reservoir mass curve and to intensify more clearly the crests and troughs of the cumulative flow records.

Abdullah Al Mamun Et al in 2018 historical rainfall data (1971–1999) from 13 rain gauges in Selangor, Malaysia, and described the characteristics of short-duration extreme rainfall within the study area. Their statement is Data on intensity–duration–frequency or design rainfall are one among the foremost important information required for various hydrological and water resources studies. it's not only tedious to work out design rainfall from the data but also occasionally impossible to calculate thanks to lack or absence of short-duration rainfall data. Conclusion is Short-duration rainfall is critical for the tiny catchments and concrete drainage systems. there's always a shortage of short-duration rainfall data because it requires automatic rain gauges to record such data.

Nandhakumar.S et al in 2019 used Curve Number method to estimate the quantity of the runoff within the Puzhal water shed. Efficient method to estimate the infiltration characteristic of the watershed in accordance with the land use/land cover property and soil property is that the curve number method. Conclusion of this paper The Soil Conservation service (SCS) and Curve Number (CN) method is employed within the present work with the assistance of land use and soil maps described in Arc GIS, as input. the quantity of runoff represented is 61.6% of the entire annual rainfall. Maximum rainfall and runoff occurred within the year 2005 and Minimum within the year 2003.

Subramani.T and Sasikala.S in 2018 made a study on Surface Runoff Estimation for Puzhal Lake Using GIS. Here three surface runoff models were connected including: the record strategy, SCS bend number technique, a semi physical thanks to affect evaluate the dissemination of surface runoff. Hence, geographic data frameworks (GIS) are presently being utilized as a neighborhood of mix with the SCS-CN technique. the entire estimated surface runoff is especially wont to plan for efficient proper water and land management in Puzhal lake study area. Toward this path, rainfall– runoff model will help in knowing the measure of runoff with the goal that the opposite editing example are often recommended for

the accessible water.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

To identified the low lying area and interconnect the possible lakes to control the flood.

3.2 OBJECTIVE

- To collect the rainfall data from (2011-2018) and to understand the amount of rainfall received in our study area and it's impact.
- To collect temperature data from (2011-2018)
- To collect the flood inundation, geomorphological, land use/cover and slope maps

3.2 SCOPE

The scope of the project is,

- To design a flood channel sewer line across our study area
- To prevent excessive rainwater entering the city
- To prevent loss of lives and property
- To prevent waterborne diseases
- To store excessive rain water and use it later

CHAPTER 4

METHODOLOGY

4.1 METHODOLOGY

The methodology of the present study is shown in the fig (), where the flowchart for the study is shown. There are various steps involved in this study. Firstly, we need to select our lakes and collect its details from the local municipality. The above-mentioned lakes details include lake surface area. Secondly, we need to collect the Rainfall data of the study area and it is collected from the Indian Institute of Water science, Taramani, Chennai and in this case, we have the daily rainfall data from the year 2011-2018. To study the rainfall pattern in our study area. We collected the temperature data in our area from the year 2011-2018 from the Indian Meteorological Department, Chennai. Runoff data for our study area is taken from the literature studies.

We need the Land use/Land cover of the recent year can be obtained from the satellite images and the toposheet map were collected from the Survey of India and also textures and slope maps and geomorphological were collected from geographic survey of India and flood inundation map from survey of India.

With the help of sketchup the Geomorphology map of our study area is designed and exported to Autodesk InfraWorks 3D and the 3D design of our study area is done. As per our idea all the lakes were interlinked via underground pipeline channels, sensors are placed in the chambers and the above is shown in our simulation

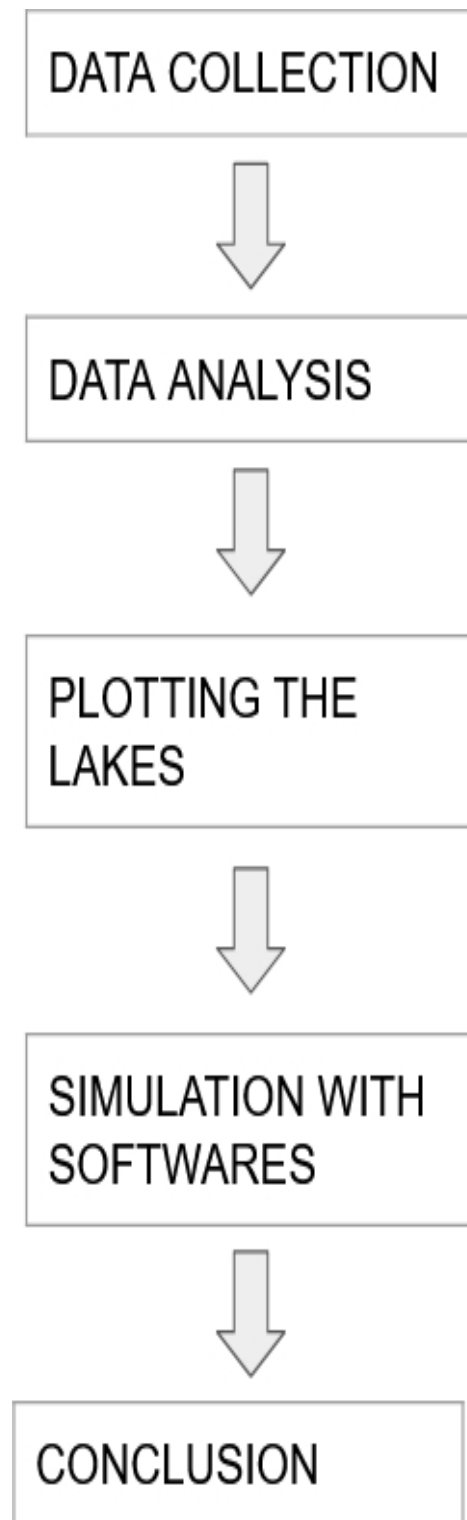


Fig 4.1 : Flowchart Of Methodology

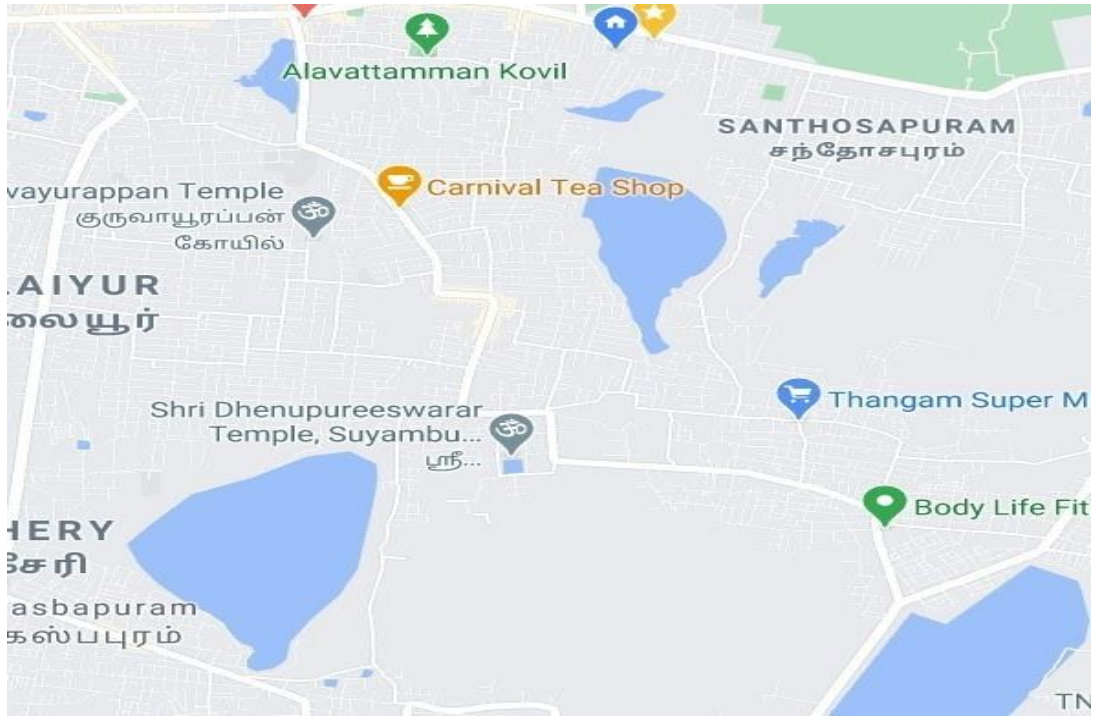


Fig: 4.2: Map of Study Area

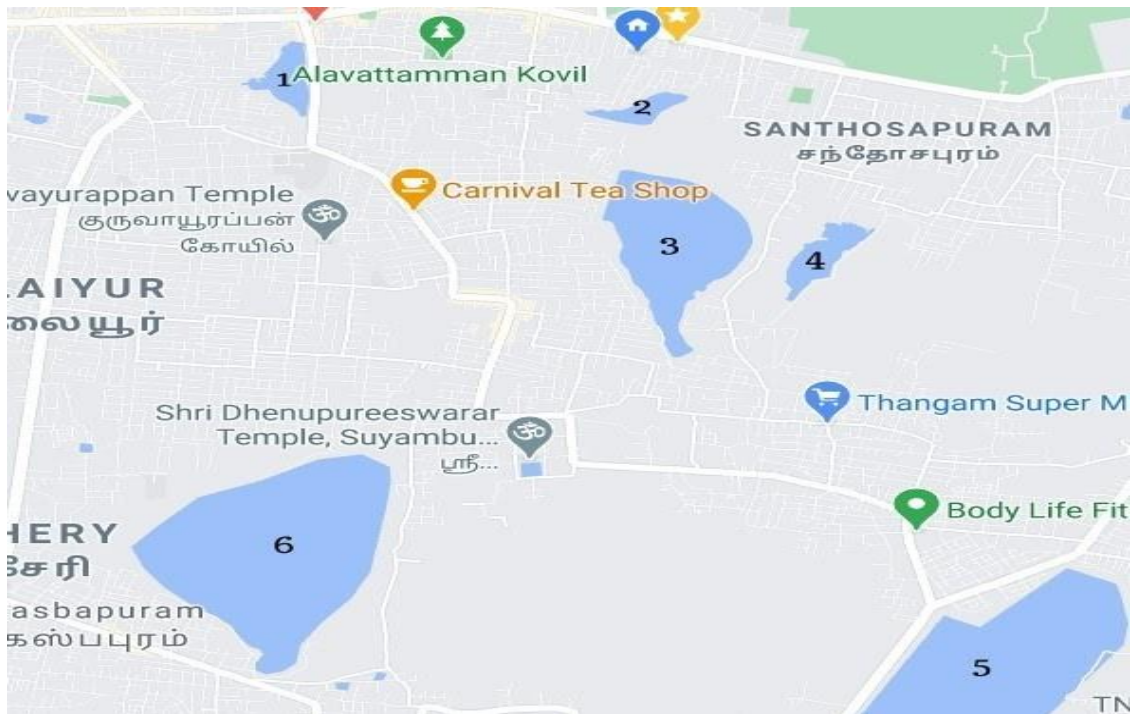


Fig 4.3 : Lakes Present In Our Study Area



Fig 4.4 : Topography

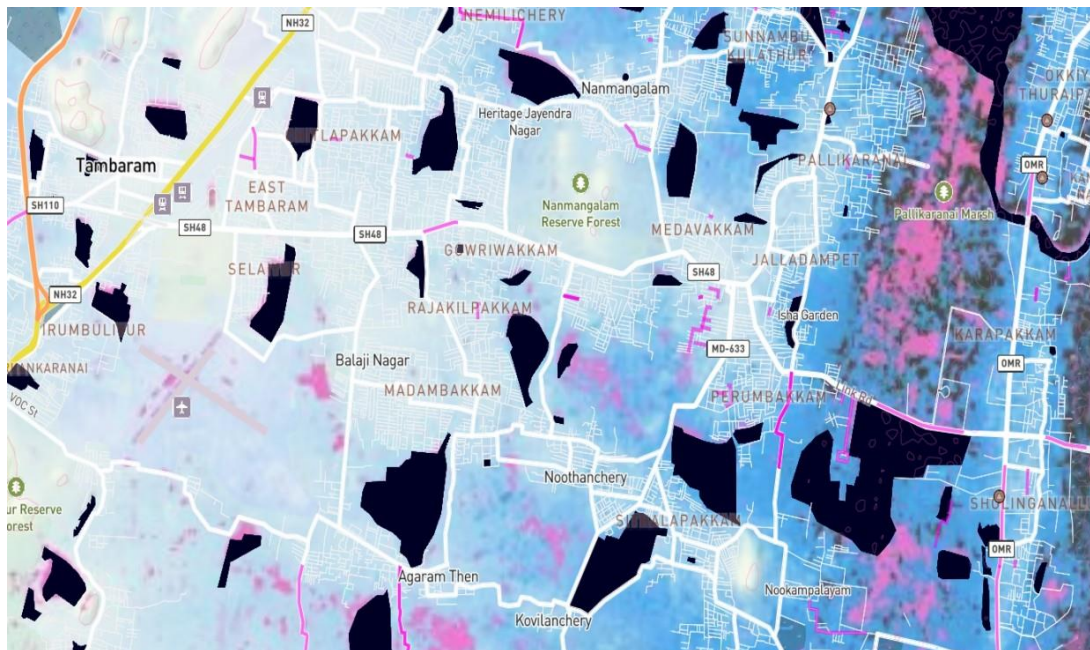


Fig 4.5 : Flood Map Of Our Study Area

4.2 DESCRIPTION OF STUDY AREA

The study area , Tambaram is a southern neighbourhood of Chennai, India, situated in Chengalpattu district ,Tamilnadu . The highway and the railway line from Chennai Egmore to Kanyakumari divide the town into East Tambaram and West Tambaram.

Tambaram is also home to the Tambaram Air Force Station of the Indian Air Force

In Tambaram, the average annual temperature is 27.8 °C The rainfall here is around 967 mm

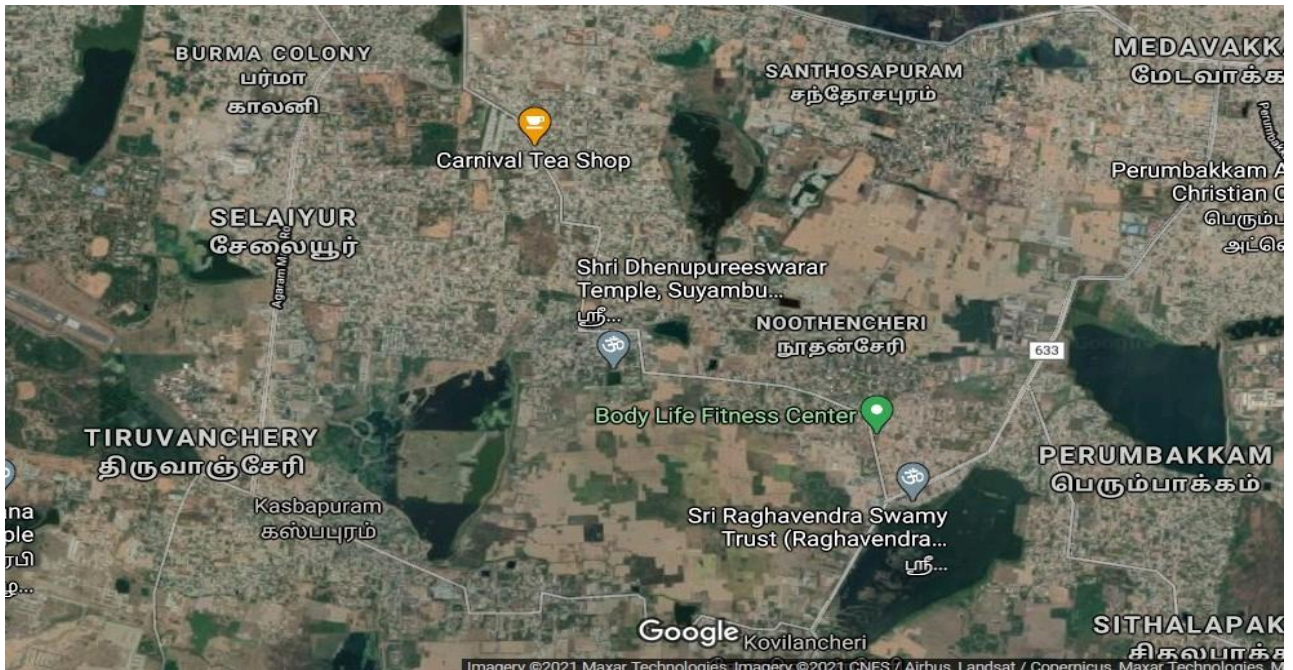


Fig 4.5 : Study Area - Tambaram

4.3 Lakes present In Our Study Area

The major lakes present in our areas are

- 1) Gowrivakkam Lake
- 2) Rajakilpakkam Lake
- 3) Madambakkam Lake
- 4) Mambakkam Lake
- 5) Agaramthen Lake
- 6) Chitrerari Lake

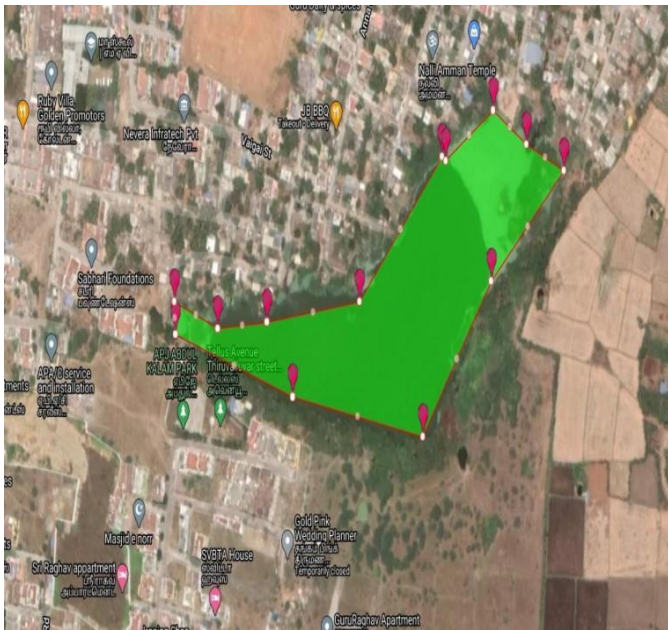


Fig 4.6 : Gowrivakkam lake

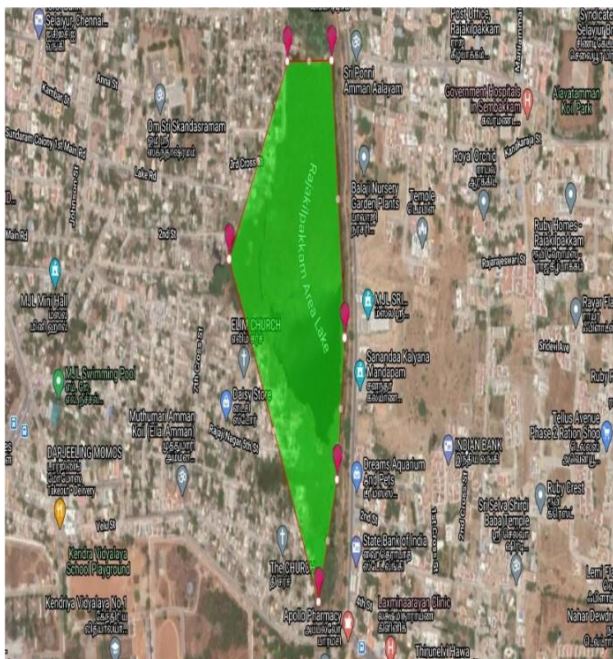


Fig 4.7 : Rajakilpakkam Lake

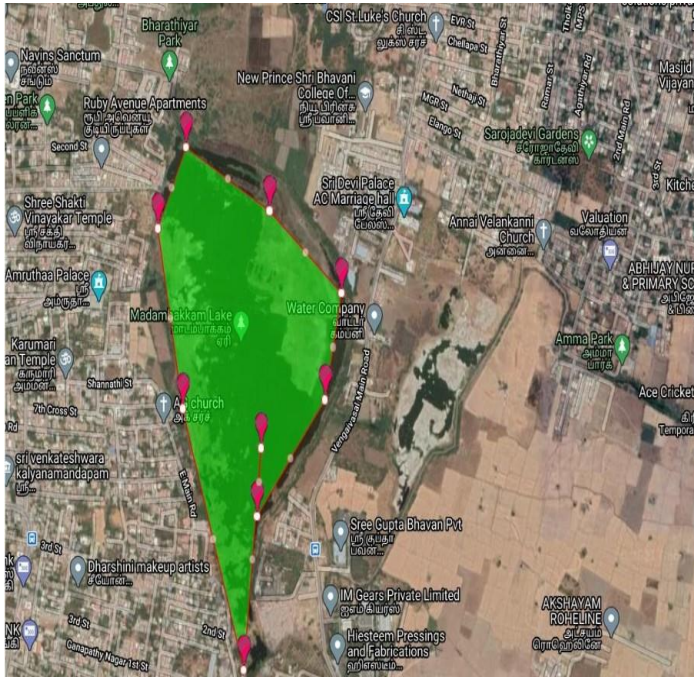


Fig 4.8 : Madambakkam Lake

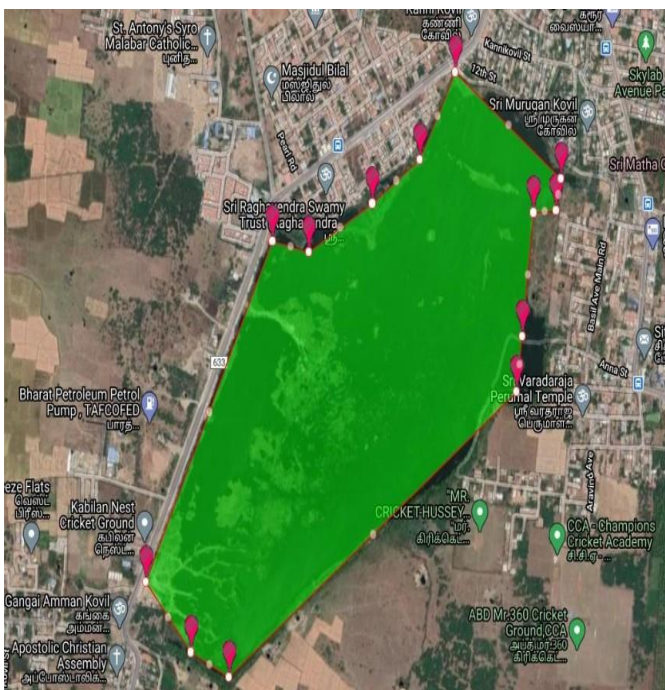


Fig 4.9 Mambakkam Lake

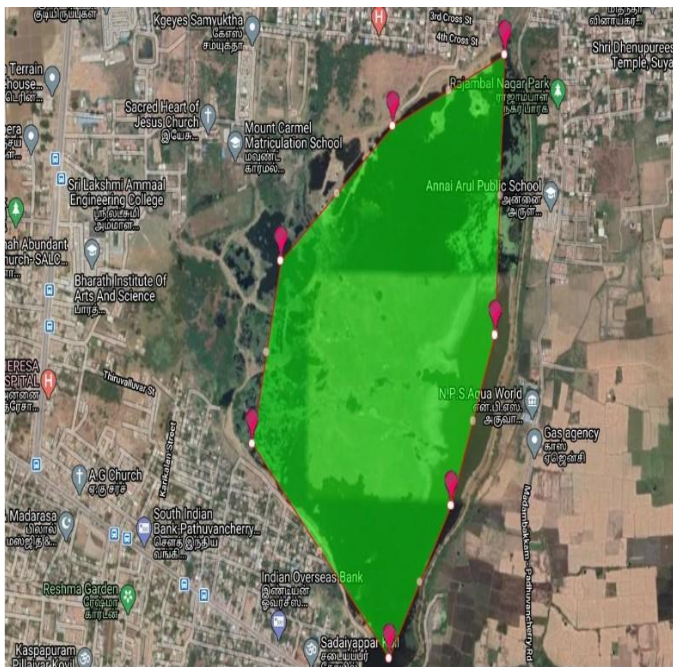


Fig 4.10 : Agaramthen Lake

1) Chitrerai Lake

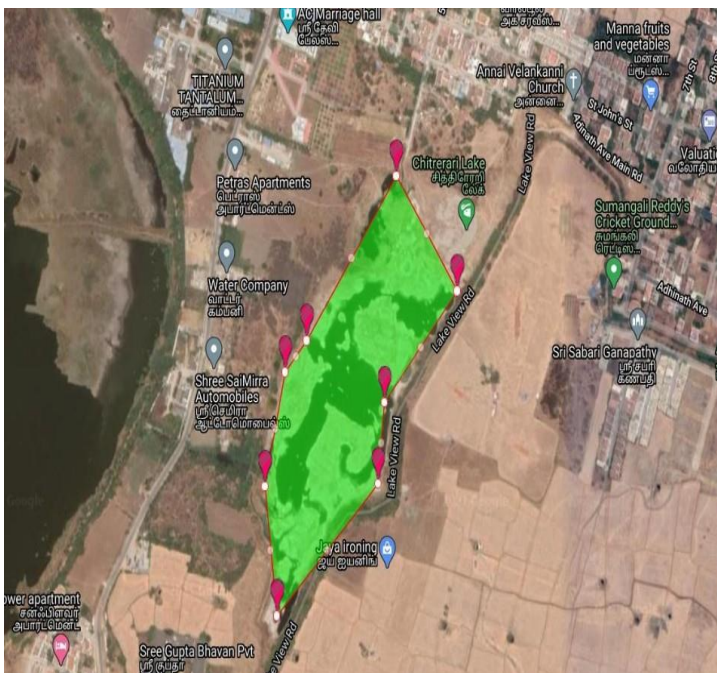


Fig 4.11 : Chitrerai lake

4.3 DATA COLLECTION

4.3.1 Rainfall data

Precipitation in arid and semi-arid zones results largely from convective cloud mechanisms producing storms typically of short duration, relatively high intensity and limited areal extent. However, low intensity frontal-type rains also are experienced, usually within the winter season. When most precipitation occurs during winter, as in Jordan and within the Negev, relatively low-intensity rainfall may represent the greater a part of annual rainfall. Rainfall intensity is defined because the ratio of the entire amount of rain (rainfall depth) falling during a given period to the duration of the amount it's expressed thorough units per unit time, usually as mm per hour (mm/h)

The statistical characteristics of high-intensity, short-duration, convective rainfall is actually independent of locations within a neighborhood and are similar in many parts of the planet . Analysis of short-term rainfall data suggests that there's a fairly stable relationship governing the intensity characteristics of this sort of rainfall. Design rainfall is defined because the total amount of rain during the cropping season at which or above which the catchment basin will provide sufficient runoff to satisfy the crop water requirements. If the particular rainfall within the cropping season is below the planning rainfall, there will be moisture stress within the plants; if the particular rainfall exceeds the planning rainfall, there will be surplus runoff which can end in damage to the structures

Water harvesting planning and management in arid and semi-arid zones present difficulties which are due less to the limited amount of rainfall than to the inherent degree of variability related to it. the planning rainfall is decided by means of a statistical probability analysis. Rainfall data is employed in calculating the AMC calculation. The rainfall data was purchased in day to day from Indian Institute Of Science And Technology ,Taramani , Chennai (Source). The day to day rainfall data is converted in monthly form as shown in table

Table : 4.1 Rainfall Data In Month Wise From 2011- 2018

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
2011	5.6	36.1	0	55.9	29.8	36.6	121	189	180	249	390	181
2012	7.9	0	0	0.1	5.9	31.6	75.1	141	93	318	95	132
2013	0	24.3	13.7	0	16.7	73.8	135	153	172	137	116	61.4
2014	0.5	3.4	0	0	35.7	117	50.9	130	130	196	135	106
2015	1.7	0	0	49.5	45.4	32.2	102	140	70.3	179	1061	574
2016	0.4	0	0	0	173	81	76	112	213	28	26	280
2017	16	0.1	0	0	14	67.8	98.8	228	98.7	287	335	49.3
2018	2.6	1.8	7.9	0.4	6.2	51.1	64.8	189	91.4	133	241	43

All data mentioned above are in mm

4.3.2 Temperature Data

Temperature may be a physical quantity that expresses hot and cold. it's the manifestation of thermal energy, present altogether matter, which is that the source of the occurrence of warmth , a flow of energy, when a body is in touch with another that's colder or hotter

Temperature is measured with a thermometer. Thermometers are calibrated in various temperature scales that historically have used various reference points and thermometric substances for definition. the foremost common scales are the Celsius scale (formerly called centigrade, denoted as °C), the Fahrenheit scale (denoted as °F), and therefore the Kelvin scale (denoted as K), the last of which is predominantly used for scientific purposes by conventions of the Systeme International d'Unites of Units (SI).

Temperature is additionally important in weather and climate. it's associated with the quantity of warmth energy within the air. Isotherm maps are wont to show how temperature is different across a neighborhood . Temperature are going to be different during different times of day, different seasons and in several places. it's suffering from what proportion heat reaches the place from the suns rays (insolation), how high the place is above the extent of the ocean , and the way much heat is delivered to the place by the movement of winds and ocean currents.

Several temperature scales exist. within the us , the Fahrenheit temperature is most ordinarily used, though the Systeme International d'Unites of Units (SI unit) Centigrade (or Celsius) is employed in most of the remainder of the planet . The Kelvin scale is employed often in physics and is adjusted in order that 0 degrees Kelvin is adequate to temperature , which is, in theory, the coldest possible temperature and at which point all kinetic motion ceases.

The average annual temperature is 27.8 °C in our study area .The below mentioned data is collected from Indian Meteorological Department , Chennai .All the info mentioned are in degree Centigrade

Table : 4.2 Monthly Average Temperature Data From The Year 2011- 2018

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC
2011	25.27	25.33	26.33	30.38	30.83	30.27	30.11	29.77	30	30.05	25.61	26.44
2012	25.83	24.83	28.94	29.27	32.05	34	30	31.77	30.44	28.83	27.83	25.61
2013	25.77	24.44	26.27	29.88	30.95	29.5	31.16	30.66	29.94	30.33	28	25.38
2014	24.94	26.33	27.11	31.6	31.38	32.61	31.38	32.55	30.27	28.77	26	25.66
2015	26.11	25.5	28.33	29.88	32.05	29.44	31.83	29.77	31.72	28.77	26.66	24.88
2016	26.33	26.11	28.66	35	32.22	32.38	31.5	29.72	28.88	30.5	27.61	24.61
2017	25.61	25.33	27.38	30.16	31.55	33.61	32.5	30.72	28.94	28.22	24.83	27.11
2018	26.05	24.72	28	30.66	32.66	32.94	30.72	31.72	29.55	30.16	26.11	27.22

4.3.3 Surface Runoff

Surface runoff (also referred to as overland flow) is that the flow of water occurring on the bottom surface when excess rainwater, stormwater, meltwater, or other sources, can not sufficiently rapidly infiltrate within the soil.

Land cover or land use is one among the factors for locating the runoff.

This map is employed for calculating each sort of land individually; this is often wont to estimate the Runoff.

Slope plays a important role in surface Runoff

Table : 4.3 Yearly Average Of Surface Runoff From 2011-2018

YEAR	RAINFALL	INFLITRATION N	DISTANCE	TOTAL RUNOFF
2011-2012	136.6	121.51	95.61	21.59
2012-2013	98.2	76.53	53.21	17.48
2013-2014	100.6	85.34	62.85	20.27
2014-2015	105.2	76.35	54.6	23.44
2015-2016	244.7	196.32	179.3	46.74
2016-2017	70.9	54.3	23.87	26.83
2017-2018	161.1	83.25	20.4	29.87

CHAPTER 5

RESULT AND DISCUSSION

5.1 MAPS

5.1.1 *Land Use/Land Cover*

LU/LC is one among the factors for locating the runoff. This map is employed for calculating each sort of land individually; this is often wont to estimate the Runoff.

For creating LU/LC map, we downloaded the Land sat 8's image of the from USGS webpage (Source), which has the spatial resolution of 30 meters, this provides a more accurate in comparison with other satellite.

We have to say the period of time as July 2018 and therefore the image should be free from cloudiness for the higher view of the map.

5.1.2 Slope Map

Slope Calculation from Contour Lines during a Topographic Map. Slope is that the measure of steepness or the degree of inclination of a feature relative to the horizontal plane. Gradient, grade, incline and pitch are used interchangeably with slope The slope is obtained by dividing the increase over run.

Slop map indicates the nearly level and elevated regions in Puzhal Watershed. It helps us to spot the Runoff flow direction and therefore the speed. The study area attains maximum elevation of 53m and minimum elevation of 6m. Primary data for mapping the slope map was downloaded from USGS webpage (Source)

5.2 LAND USE/LAND COVER

The watershed cover and includes all kinds of vegetation, litter and mulch and fallow also as non-agricultural uses, like water surfaces, roads, roofs etc. it affects infiltration. A forest soil, rich in organic matter, allows greater infiltration than a paved one in urban areas. On an agricultural land or a land surface with loose soil whose particles are easily detached by the impact of rainfall, infiltration is suffering from the method of rearrangement of those particles within the upper layers such the pores are clogged resulting in reduction within the infiltration rate. The land use and treatment classes are often broadly classified into urban land, farmland, and woods and forest.

The larger the impervious area, the upper are going to be the runoff potential of the watershed and vice-versa. In urban areas, the percent imperviousness is essentially governed by the population density. The larger the population density, the larger are going to be the imperviousness. The agricultural land uses are classified as fallow land row crops, small grain crops, close-seeded legumes or rotation meadow, pasture or range and meadow. Fallow refers to reveal agricultural land having the very best runoff potential. Planting the crops in rows on contours increases infiltration and hence decreases runoff. Woods are usually small isolated grooves of trees raised for farm use. Forests generally cover a substantial a part of a watershed. Humus increases with the age of forest. due to its porous nature, it increases Infiltration and hence decreases runoff.

LU/LC is one among the important factors in calculating the runoff calculation .it is created using ERDAS software and Arc GIS software. Level – I classification Table 5.3 is completed during this study. The LU/LC of our study area is shown in Fig: 5.2. Land use/land cover mapping is completed under level 1 category; it includes Built-up land, agricultural land, range land forest land, water, wetland, barren land, tundra, perennial snow or ice as shown in table 5.3.

Table 5.1: Land use and land cover classification system for use with RS data

Sl. No	Level – I	Level - II
1	Built-up Land	Residential, Commercial and Services, Industrial, Transportation, Communications and Commercial Complexes
2	Agricultural Land	Cropland and Pastureland, Plantation, Orchards, Groves, Vineyards, Nurseries, Ornamental Horticultural Areas, Confined Feeding Operations and Other Agricultural Land
3	Rangeland	Herbaceous Rangeland, Shrub, Brush Rangeland and Mixed Rangeland.
4	Forest Land	Deciduous Forest Land, Evergreen Forest Land and Mixed Forest Land.
5	Water	Streams and Canals, Lakes, Reservoirs, Bays and Estuaries.
6	Wetland	Forested Wetland and Non-forested Wetland.
7	Barren Land	Dry Salt Flats, Beaches, Sandy Areas other than Beaches, Bare Exposed Rock, Strip Mines. Quarries, Gravel Pits Transitional Areas and Mixed Barren Land.
8	Tundra	Shrub and Brush Tundra, Herbaceous Tundra, Bare Ground Tundra, Wet Tundra and Mixed Tundra.
9	Perennial Snow or Ice	Perennial Snowfields and Glaciers

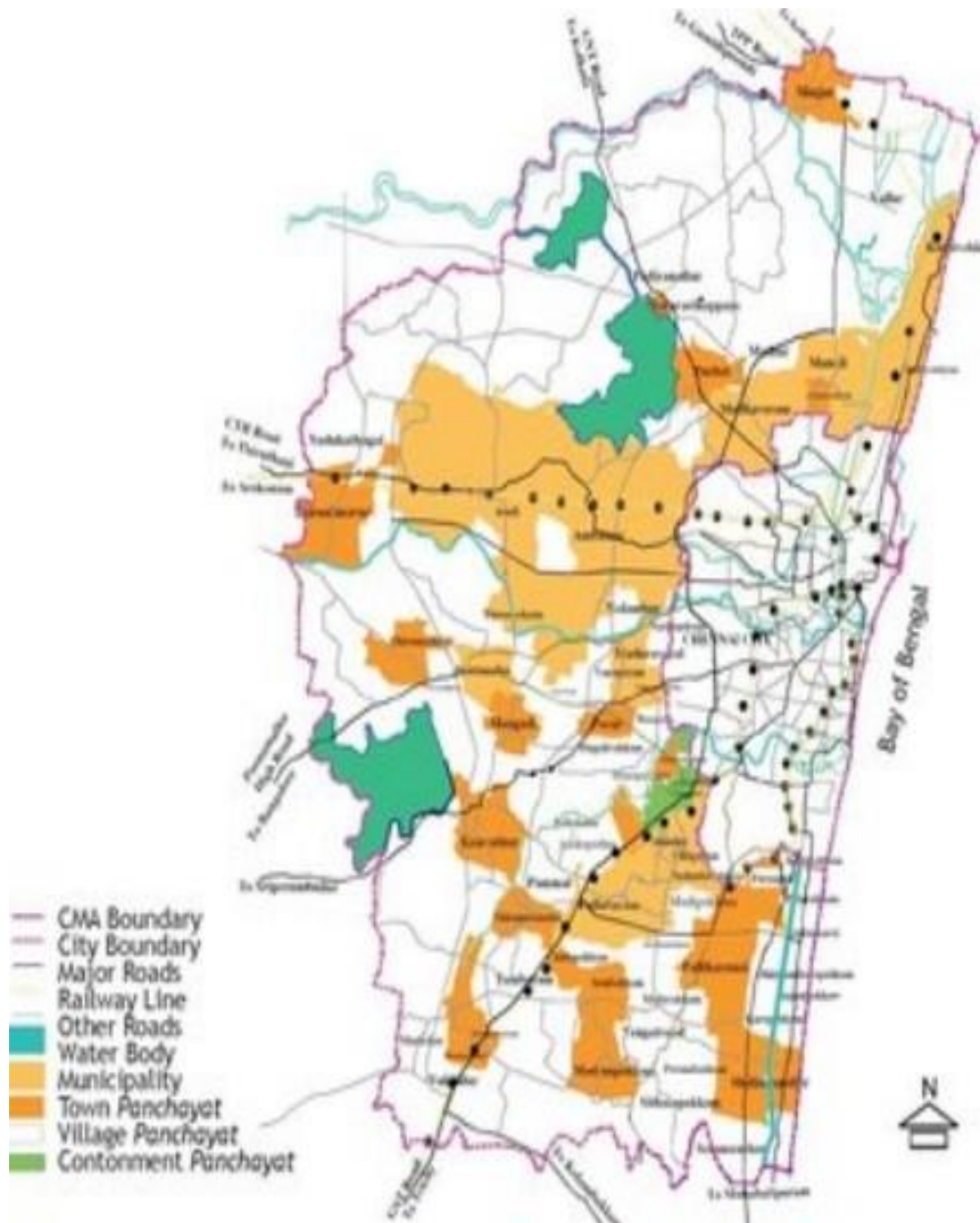


Fig: 5.1: Land use / Land cover of Study Area

From the Land use/land cover map shows that the Puzhal watershed covers 5299901.53sq-km agricultural land, 62137517.23sq-km - built-up land,, 2505627.42sq- km -barren land,1022569.25sq-km – forest,96946.59sq-km - road,30842442.71sq-km - water bodies,50872713.19sq-km –vegetation and utilized in runoff estimation. The result from LU/LC for the study area is shown during a Table .4

Table 5.2: Area calculation in Our Study Area

SI. NO	CLASSES	Area in Sq. m
1	Agricultural Area	5299901.53
2	Built-up Land	62137517.23
3	Forest	1022569.25
4	Waste Land/Barren Land	2505627.42
5	Water Bodies	30842442.71
6	Road	96946.59
7	Vegetation	50872713.19

5.3 SLOPE MAP

Slope mapping is completed using Arc GIS software. It indicates the elevated region and depressed region in Tambaram . It indicates that the runoff will be due west to east direction. Tambaram comes under gentle to slop class as shown in Table 5.5 (Medium to high runoff) thus improving infiltration and recharge

in the study area shown in Fig: 5.2

In GIS mapping slope are often vital for a spread of reasons including suitability analysis, predictive modeling, and predicting potential hazards. Analyzing the terrain slope of a given location plays a crucial part in fields like hydrology, site planning, conservation, and infrastructure development. Slope are often calculated from a Digital Elevation Model which form a crucial a part of many GIS datasets; equally important are the parameters and techniques wont to calculate terrain slope also as other analyses performed with a DEM. In Suitability analysis or predictive modeling, by calculating the slope within a GIS, areas are often eliminated that are not suitable or that do not fit within the model. In predicting potential hazards, areas are often seen as dangerous thanks to the steepness of a slope. this is often a really powerful and useful gizmo in GIS. Slope is calculated during a GIS by comparing a particular point within a raster thereto point's neighbors. Usually some extent is compared with eight of its neighbors to derive its slope, but the precise method varies counting on the precise slope analysis desired.

Table 5.3: Slope Classes of our Study Area (IMSD 1995)

Sl. No.	%Slope	Area in Km ²	Implication of Potential
1	Nearly Level	33.76 Km ²	Low surface runoff
2	Gentle	31.76 Km ²	Low surface runoff
3	Moderate	46.69 Km ²	Medium surface runoff
4	Steep	38.22 Km ²	High surface runoff
5	Very Steep	11.78 Km ²	High surface runoff

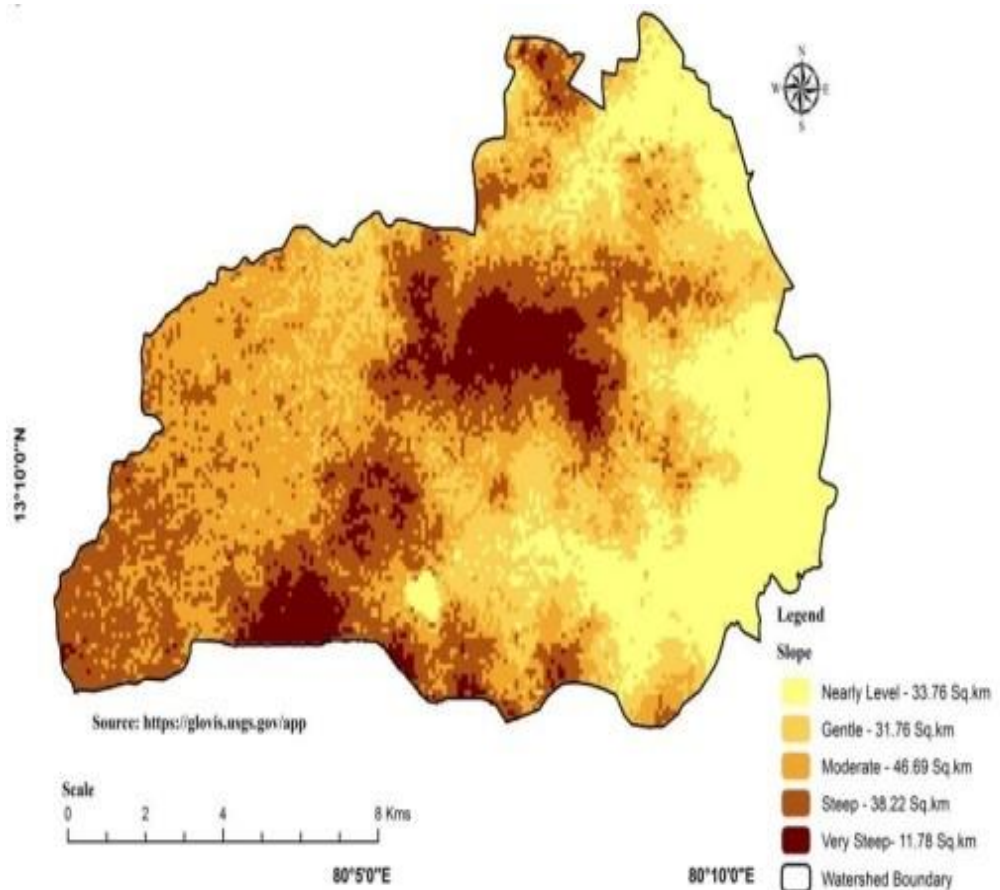


Fig: 5.2: Slope map Of study Area

5.4 Rainfall Data

The rainfall data was collected from Indian Institute Of Water Science , Taramani , Chennai from the year 2011 to 2018 . with the above mentioned data graphs were plotted . From plotted graphs maximum and minimum rainfall occurred in month year wise and amount of rainfall was identified . Average rainfall and percentage of rainfall was calculated from our analysis

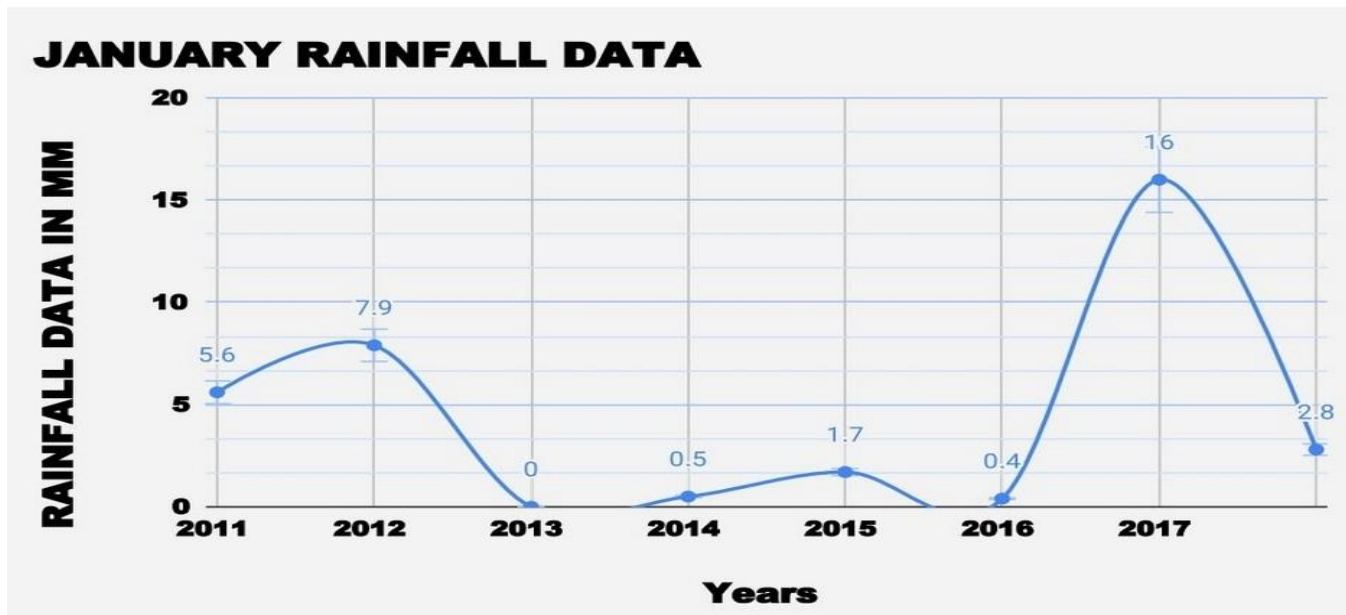


Fig : 5.3 January Graph Rainfall vs Years

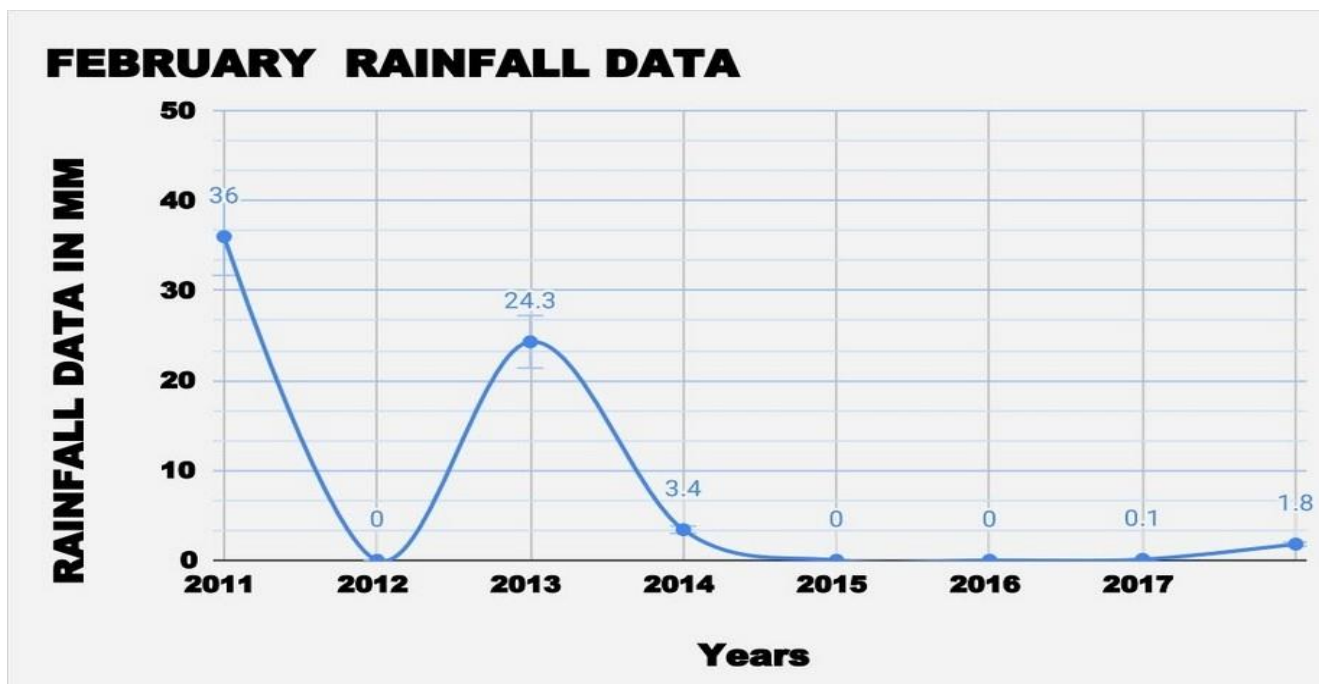


Fig : 5.4 February Graph Rainfall vs Years

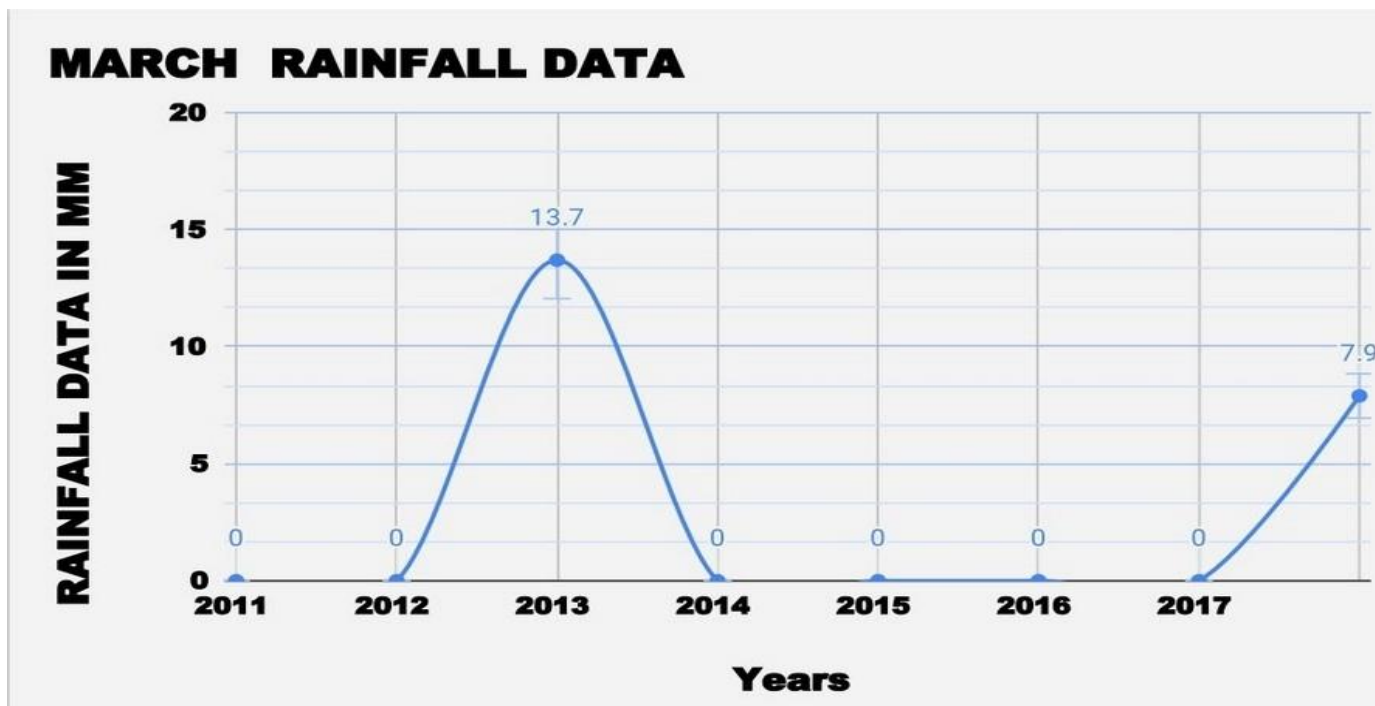


Fig : 5.5 March Graph Rainfall vs Years

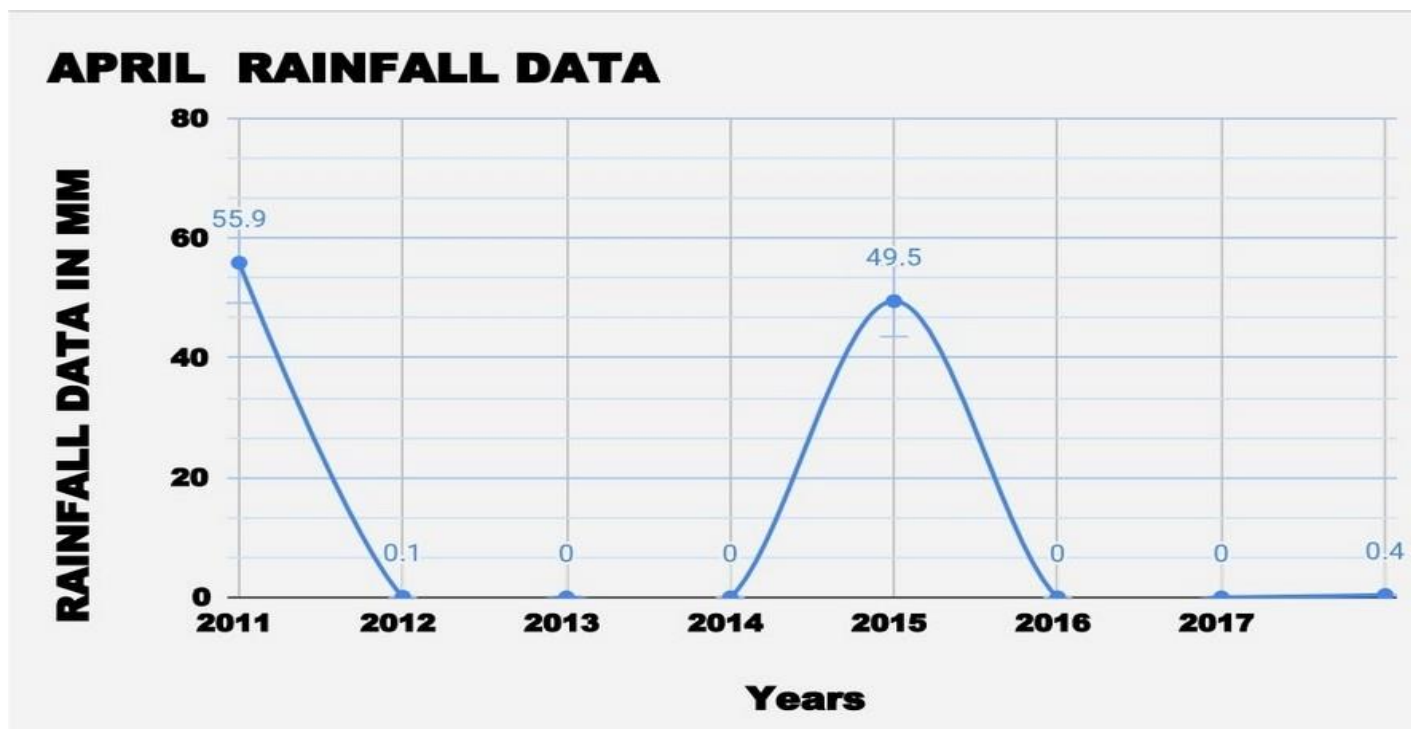


Fig : 5.6 April Graph Rainfall vs Years

MAY RAINFALL DATA

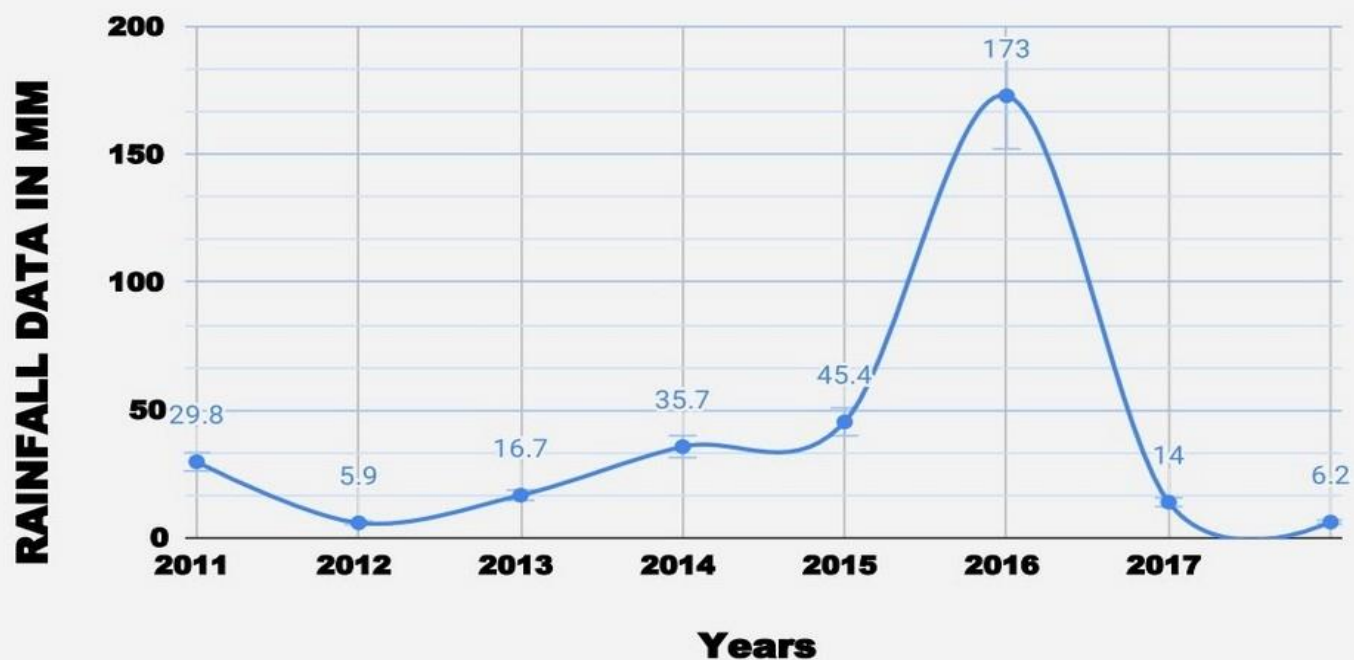


Fig : 5.7 May Graph Rainfall vs Years

JUNE RAINFALL DATA

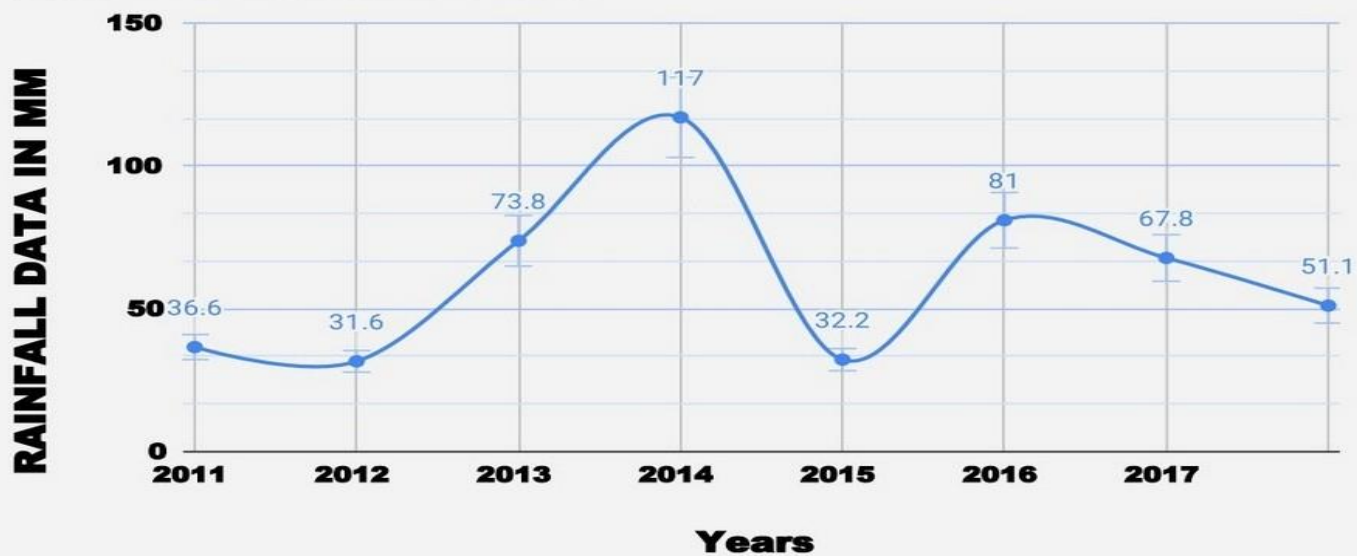


Fig : 5.8 June Graph Rainfall vs Years

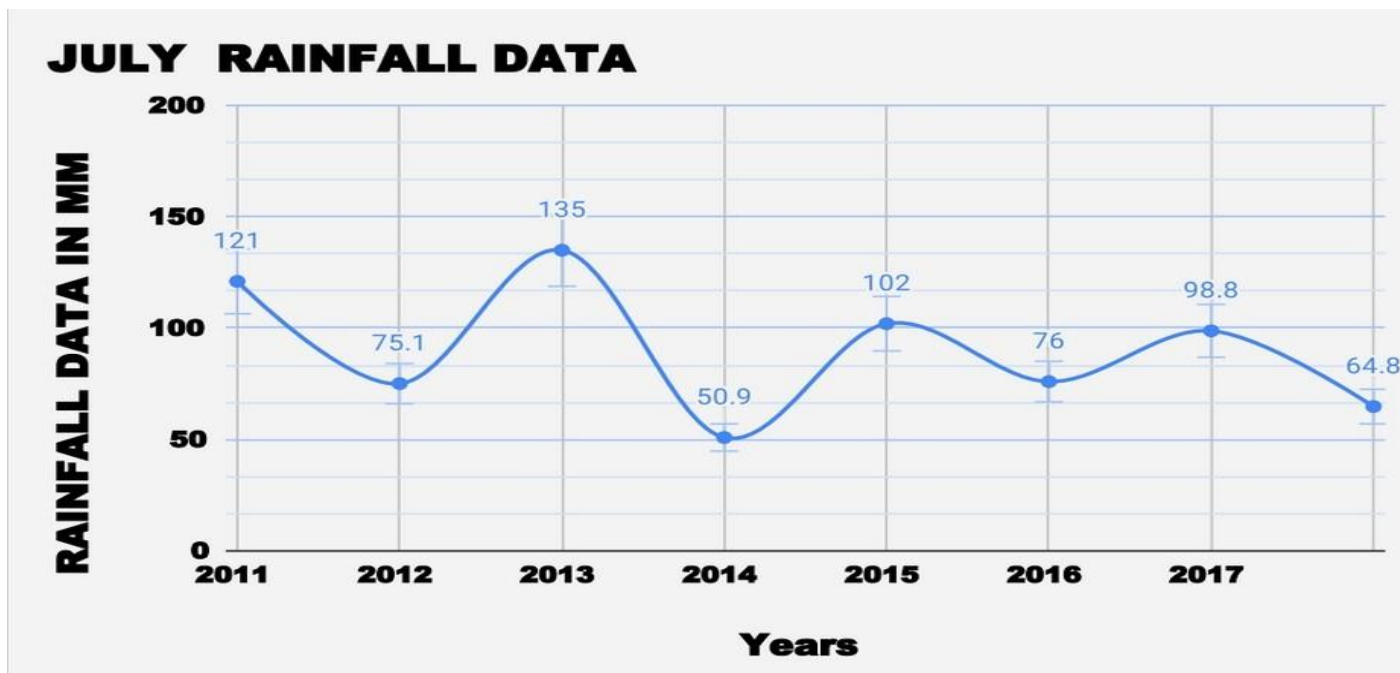


Fig : 5.9 July Graph Rainfall vs Years

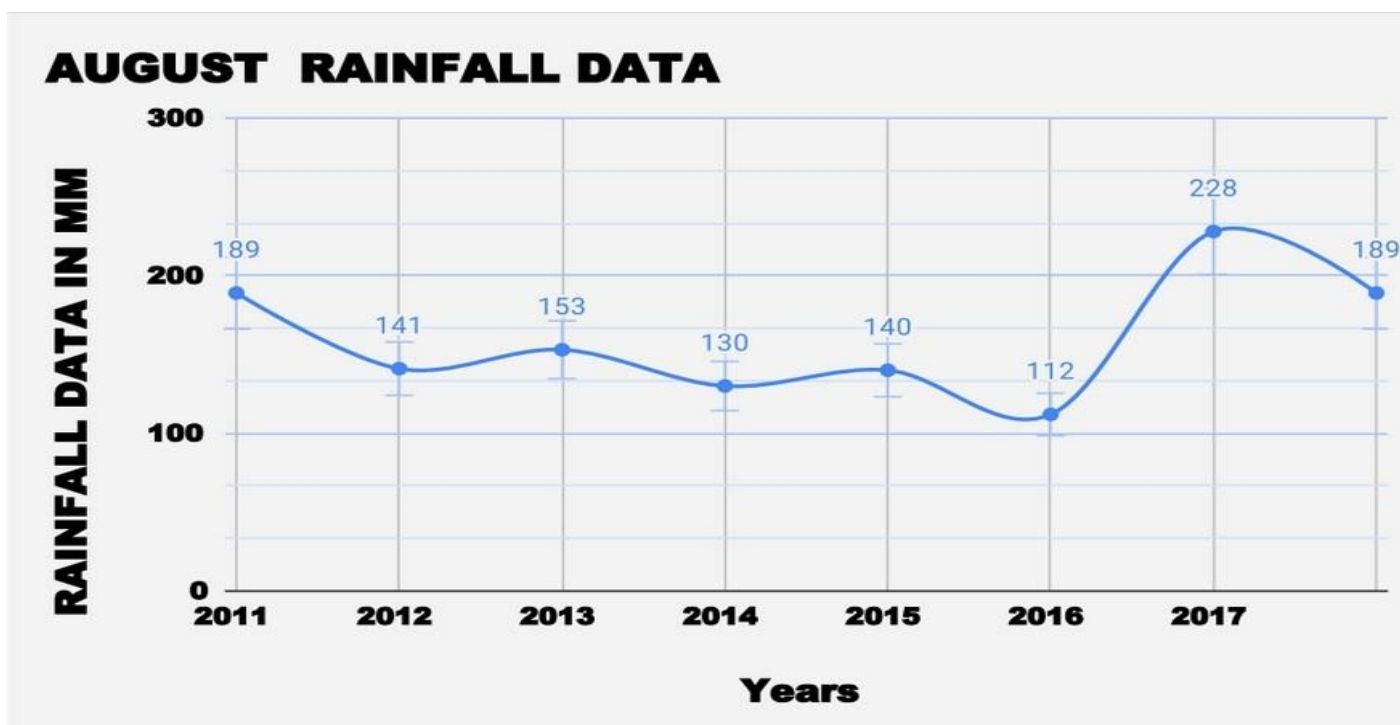


Fig : 5.10 August Graph Rainfall vs Years

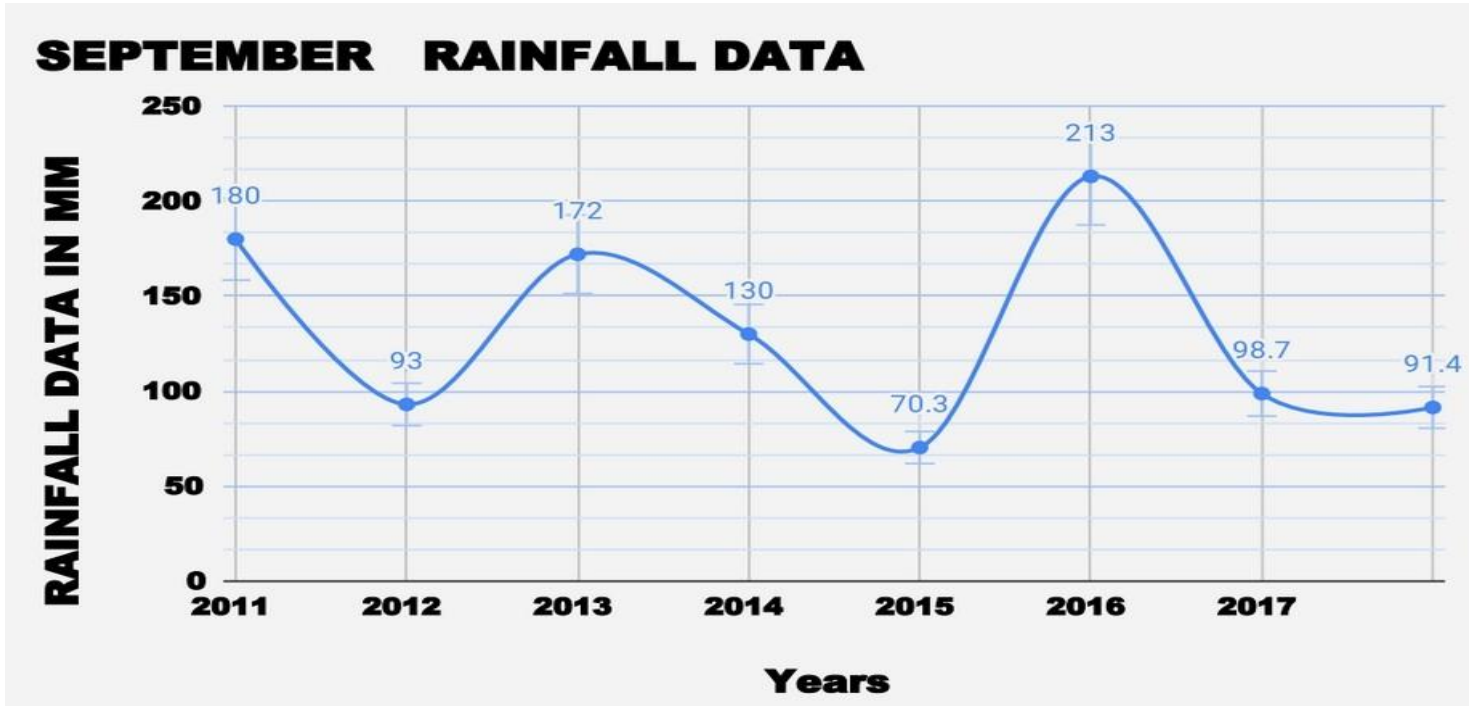


Fig : 5:11 September Graph Rainfall vs Years

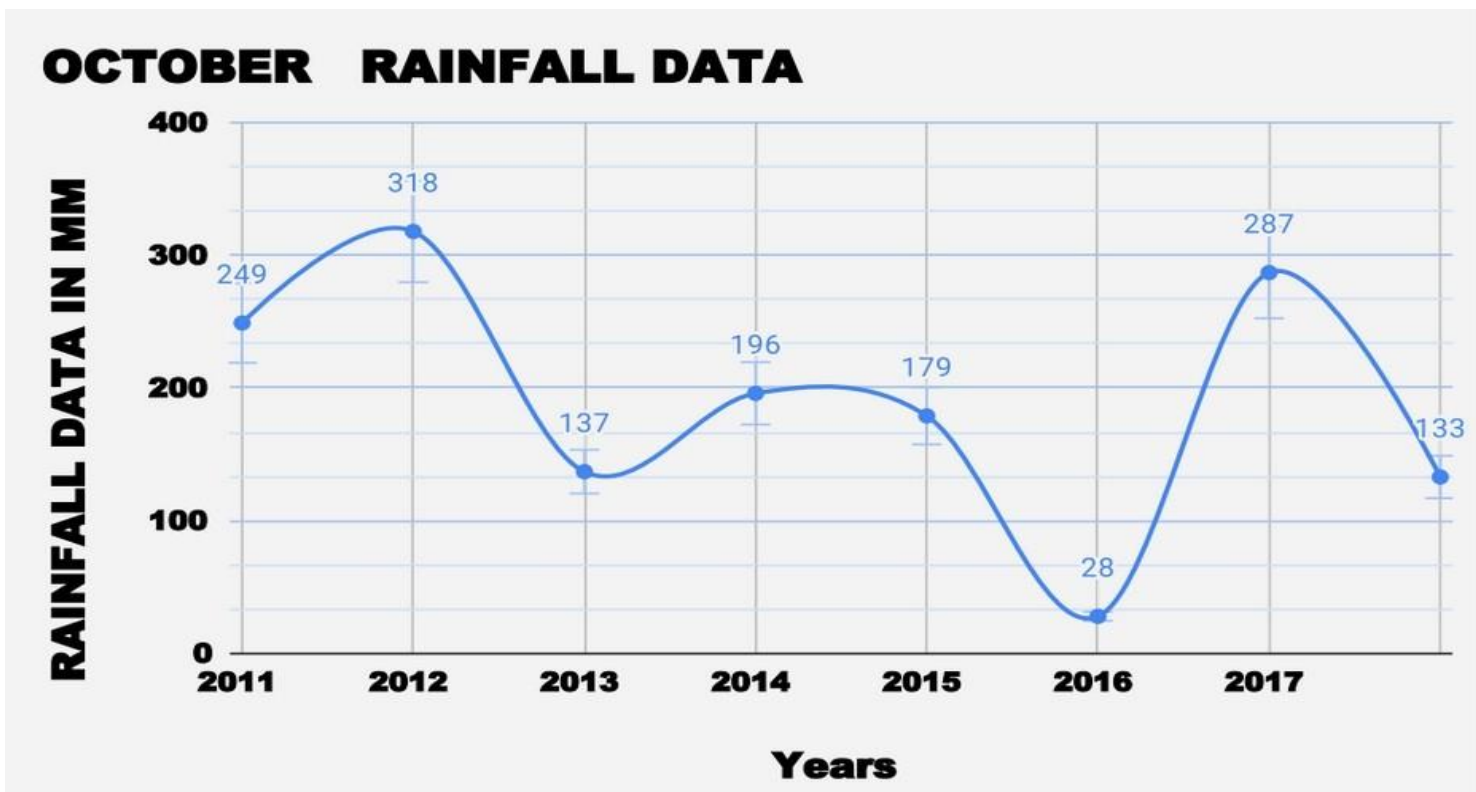


Fig : 5:12 October Graph Rainfall vs Years

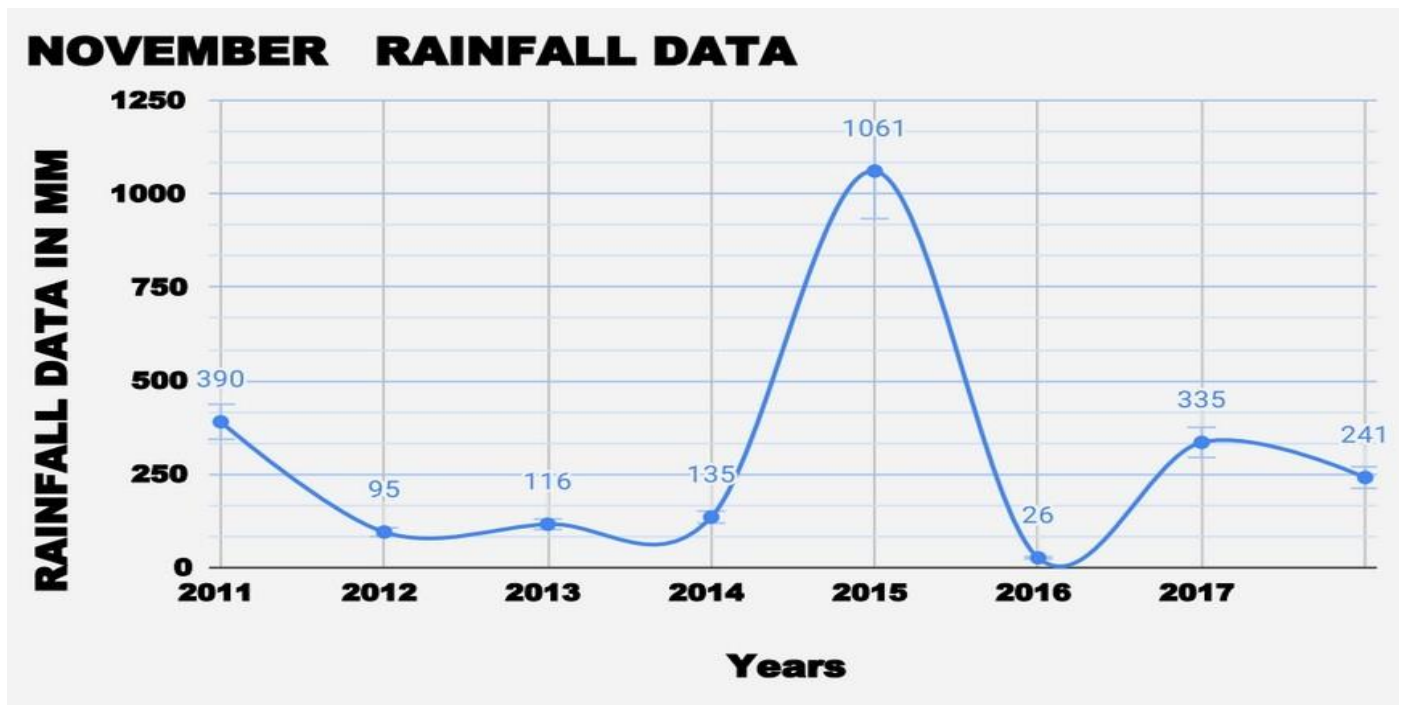


Fig : 5:13 November Graph Rainfall vs Graph

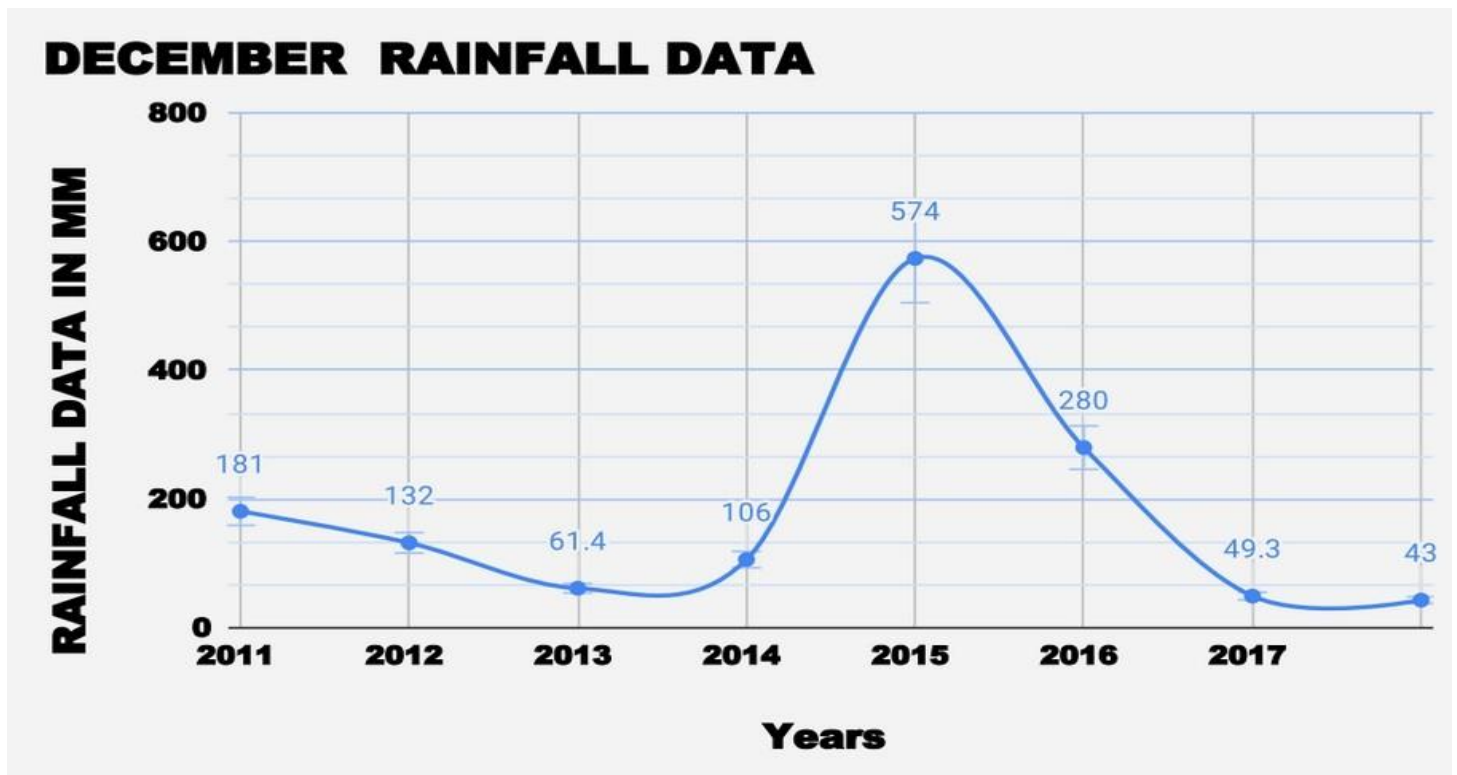
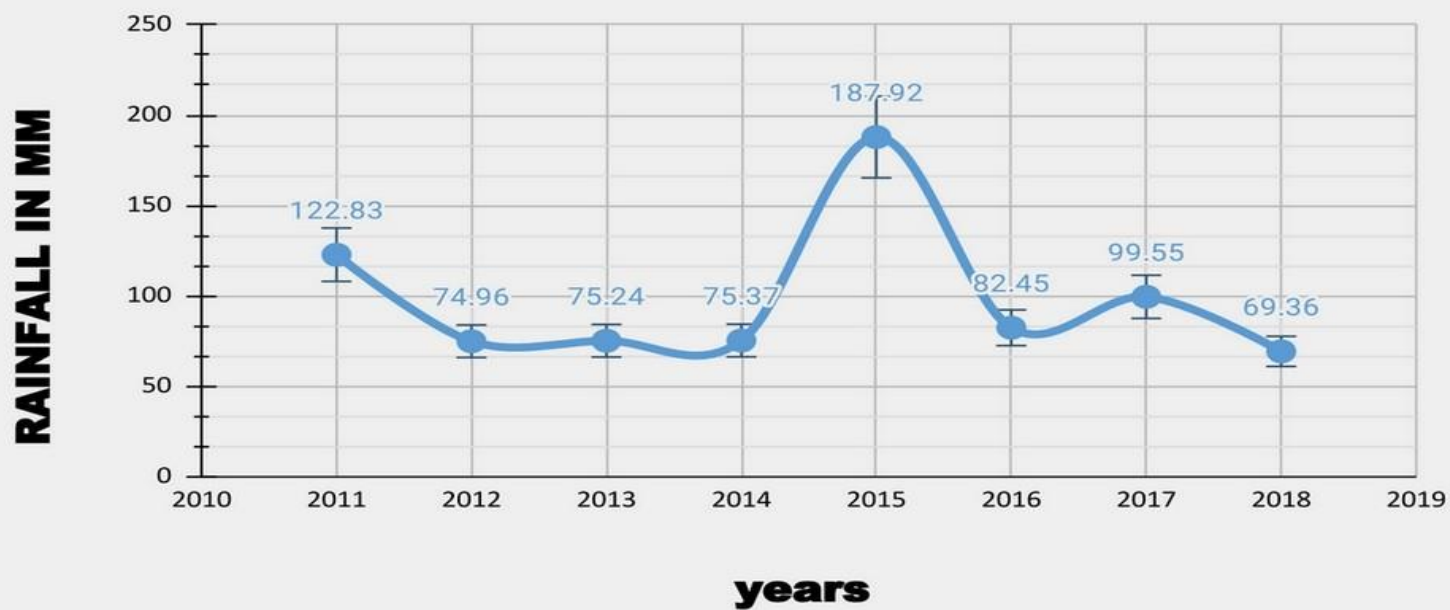


Fig : 5.14 December Graph Rainfall vs Years

AVERAGE RAINFALL



AVERAGE RAINFALL

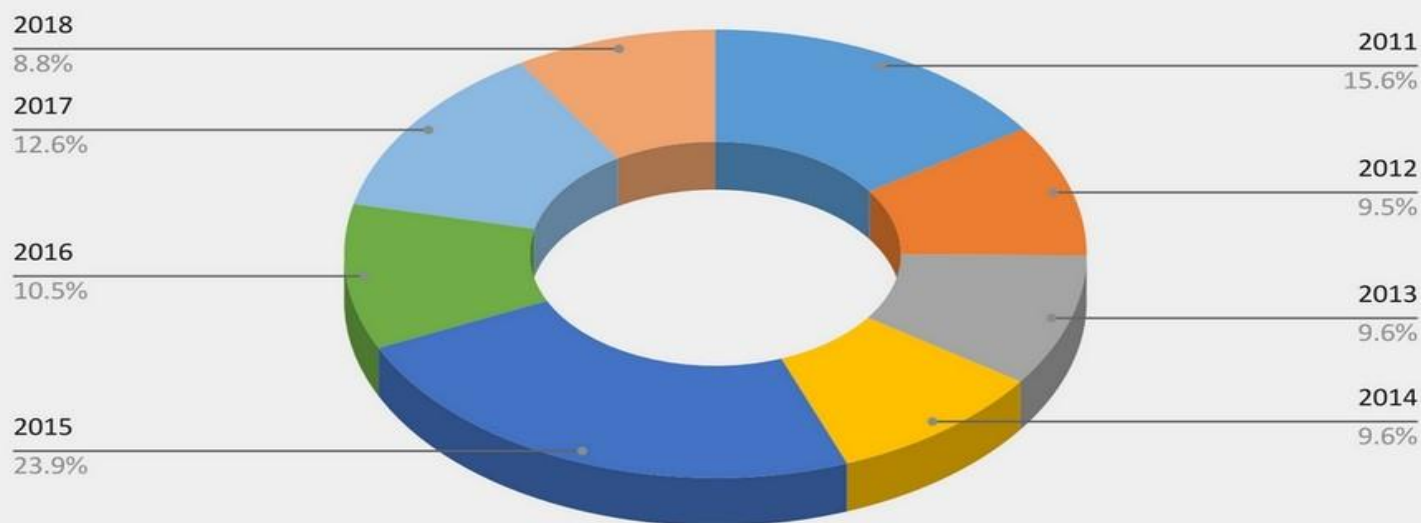


Fig : 5.15 Average Rainfall In Our Study Area

5.5 Temperature Data

The temperature data was collected from Indian Meteorological Data for the year 2011- 2018 with the collected data with the collected data graph were plotted with plotted graph maximum and minimum Temperature were know and relationship between temperature and rainfall was acknowledged

January Temperature Data

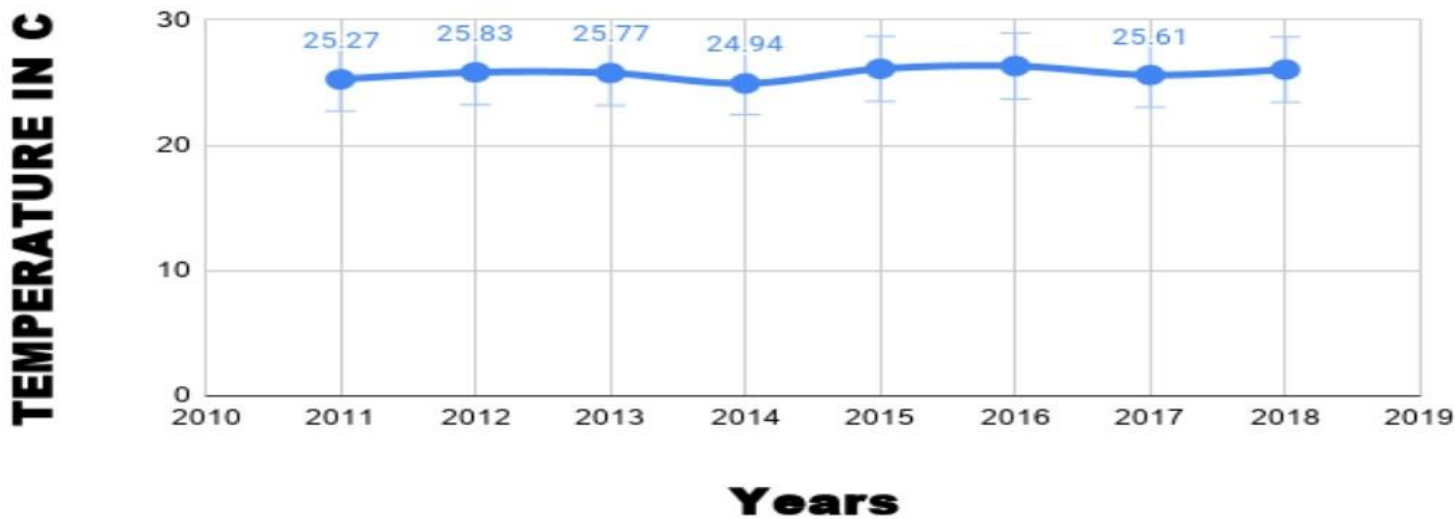


Fig : 5.16 January temperature graph vs years

February Temperature Data

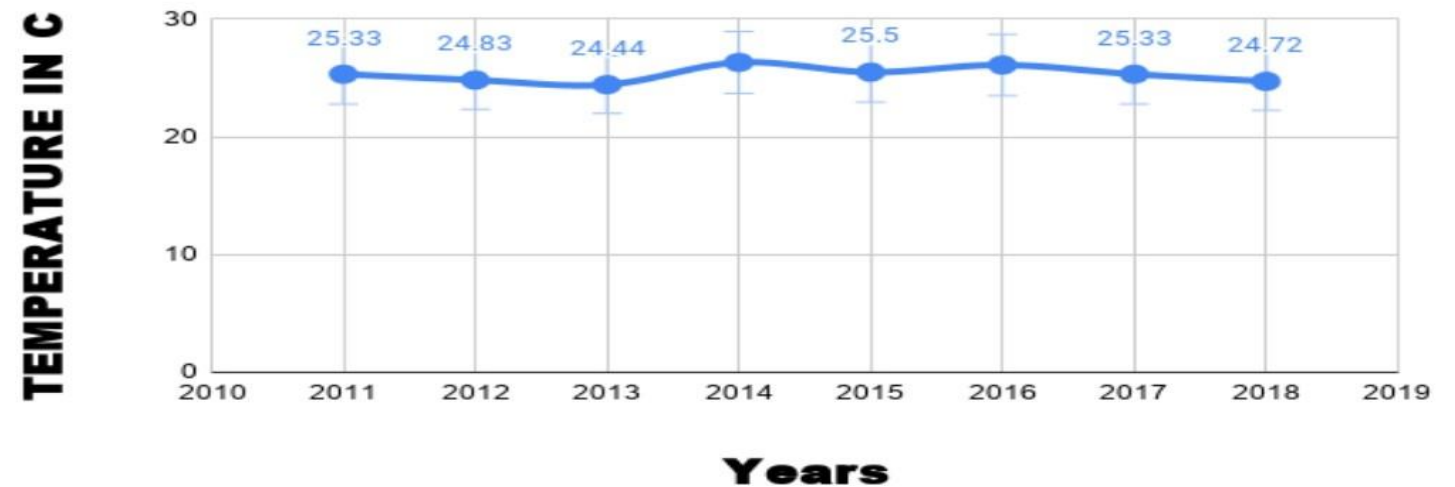


Fig : 5.17 February Temperature graph vs years

March Temperature Data

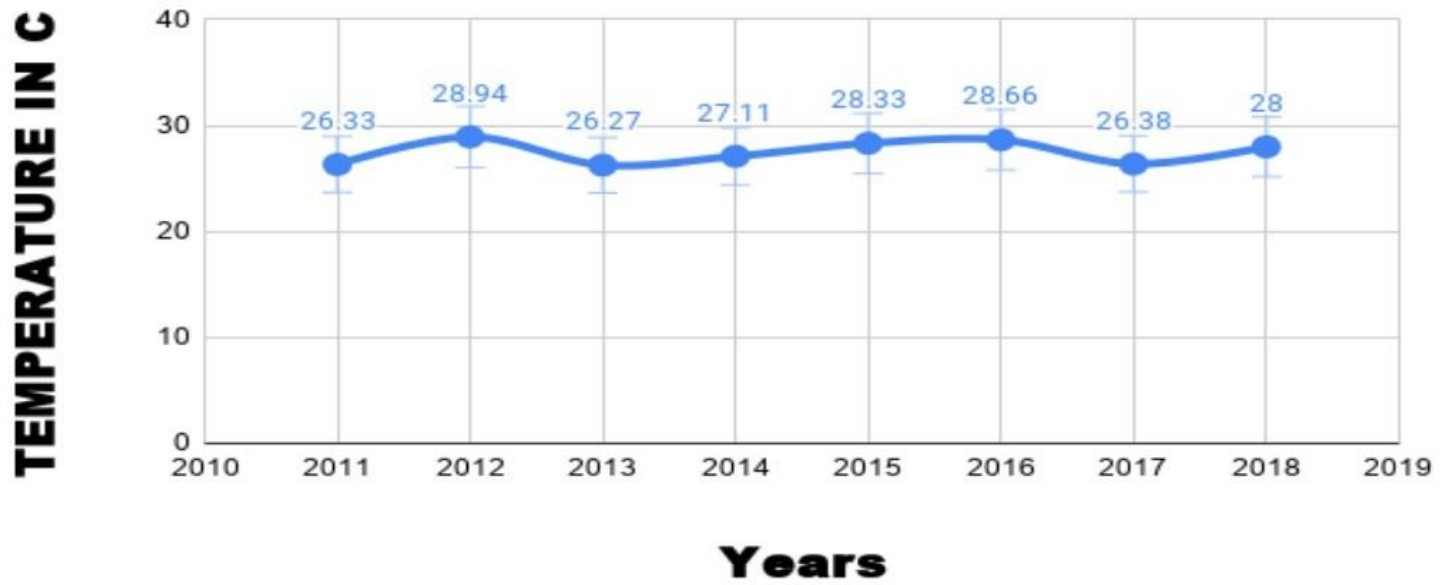


Fig : 5.18 March Temperature graph vs years

April Temperature Data

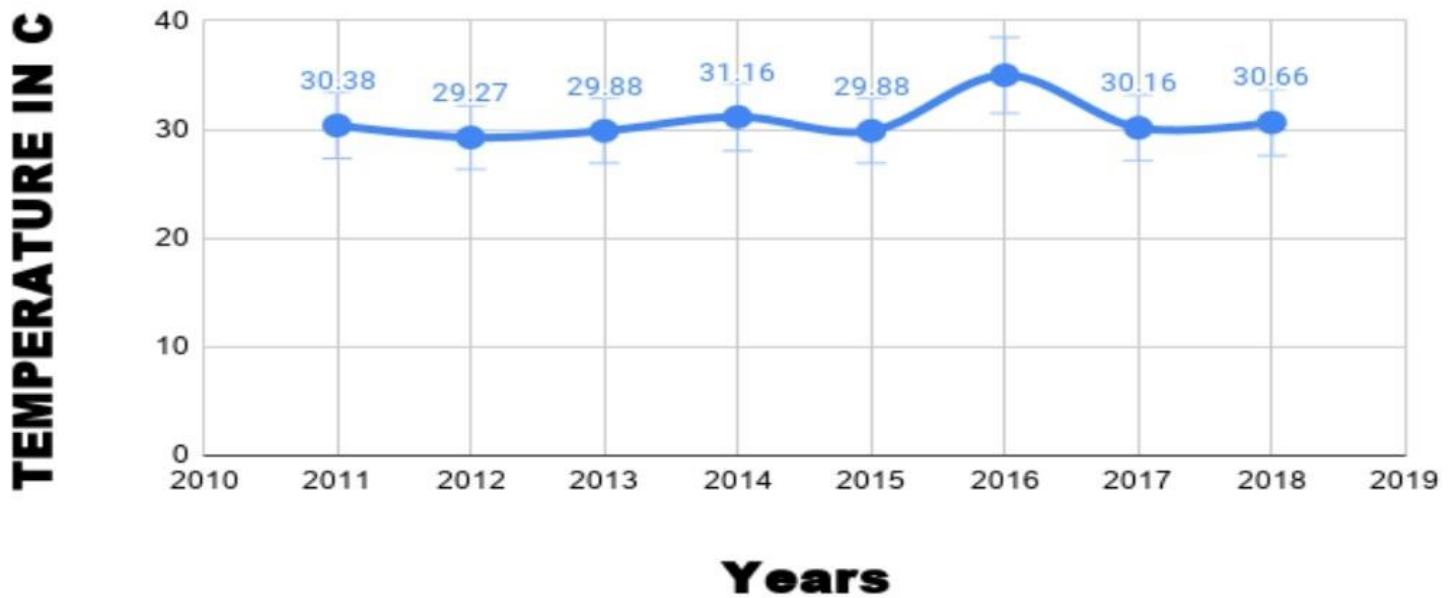


Fig : 5.19 April Temperature graph vs years

May Temperature Data

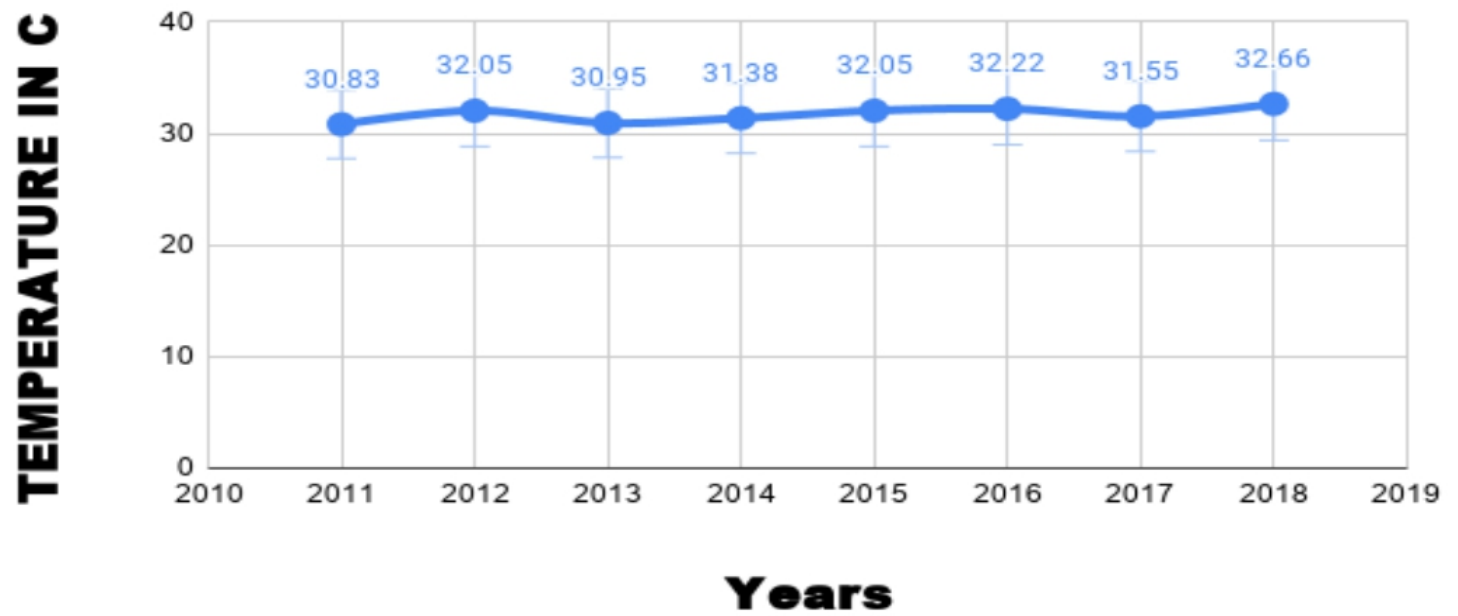


Fig : 5.20 May Temperature graph vs years

June Temperature Data

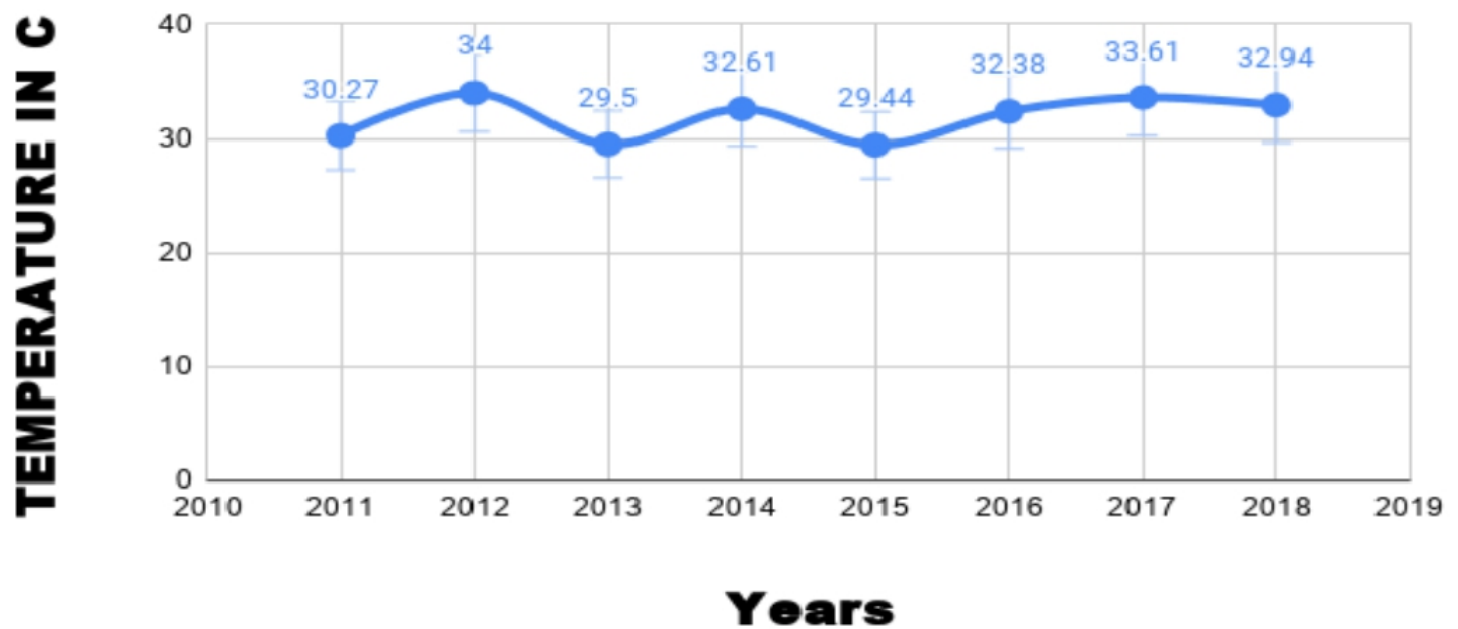


Fig : 5.21 June Temperature graph vs Years

July Temperature Data

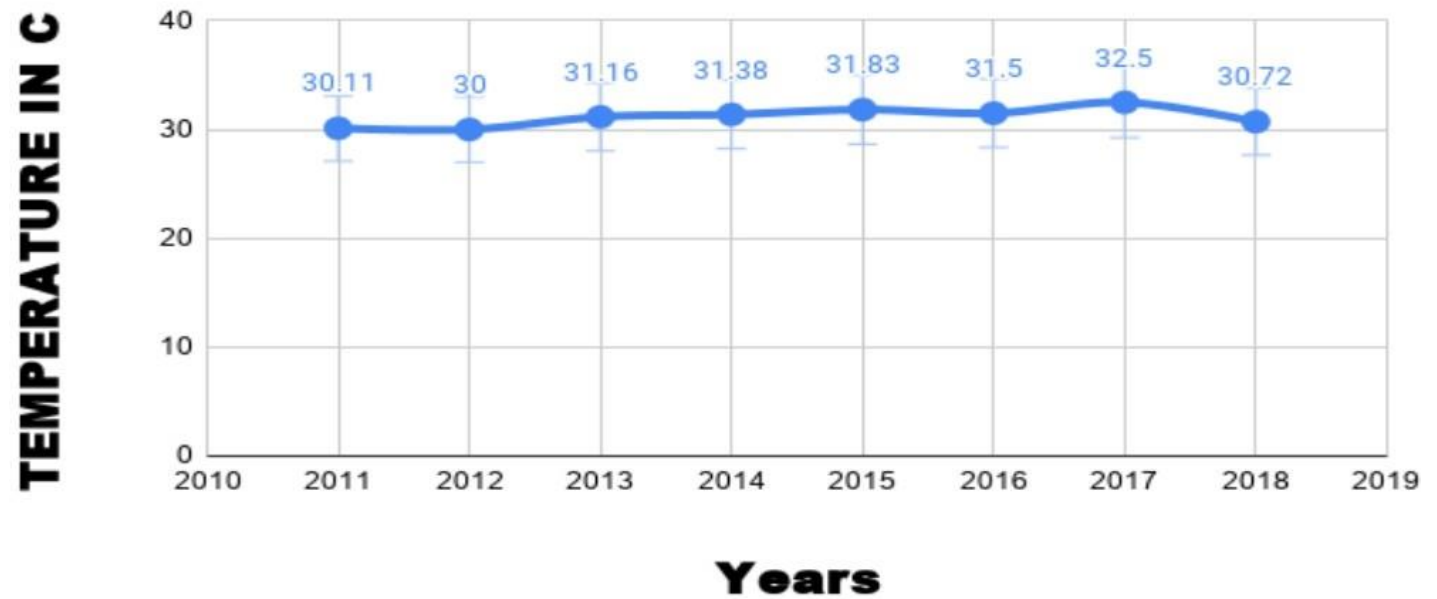


Fig : 5.22 July Temperature graph vs Years

August Temperature Data

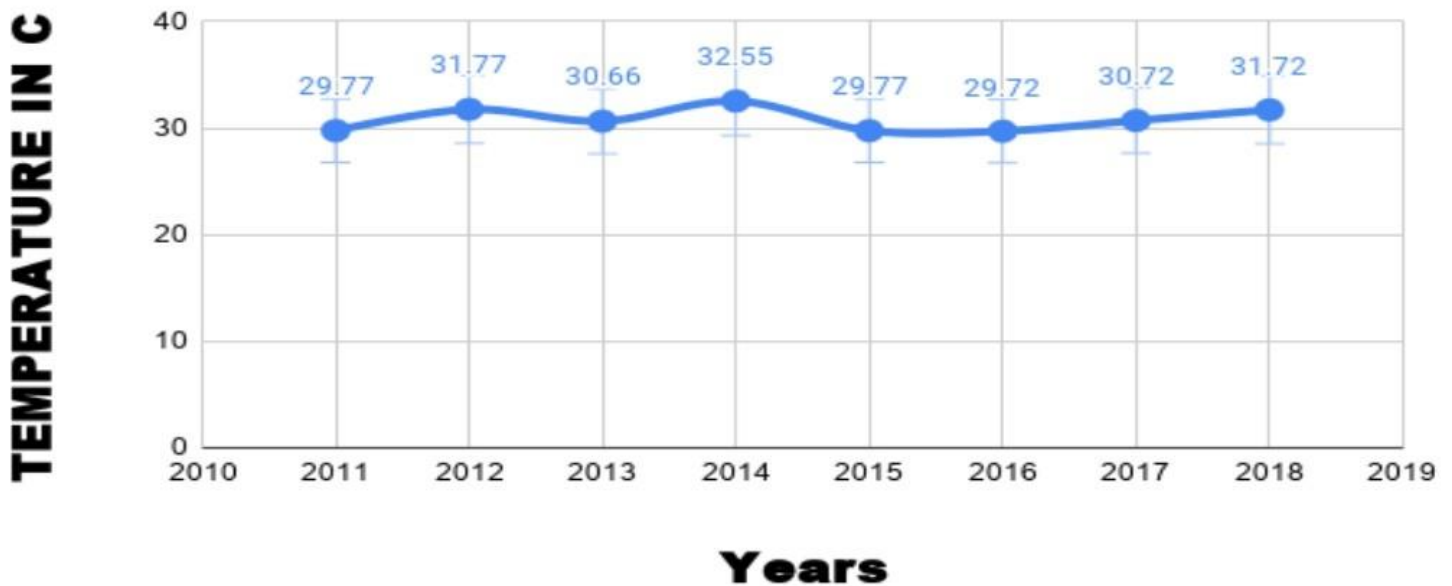


Fig : 5.23 August Temperature graph vs Years

September Temperature Data

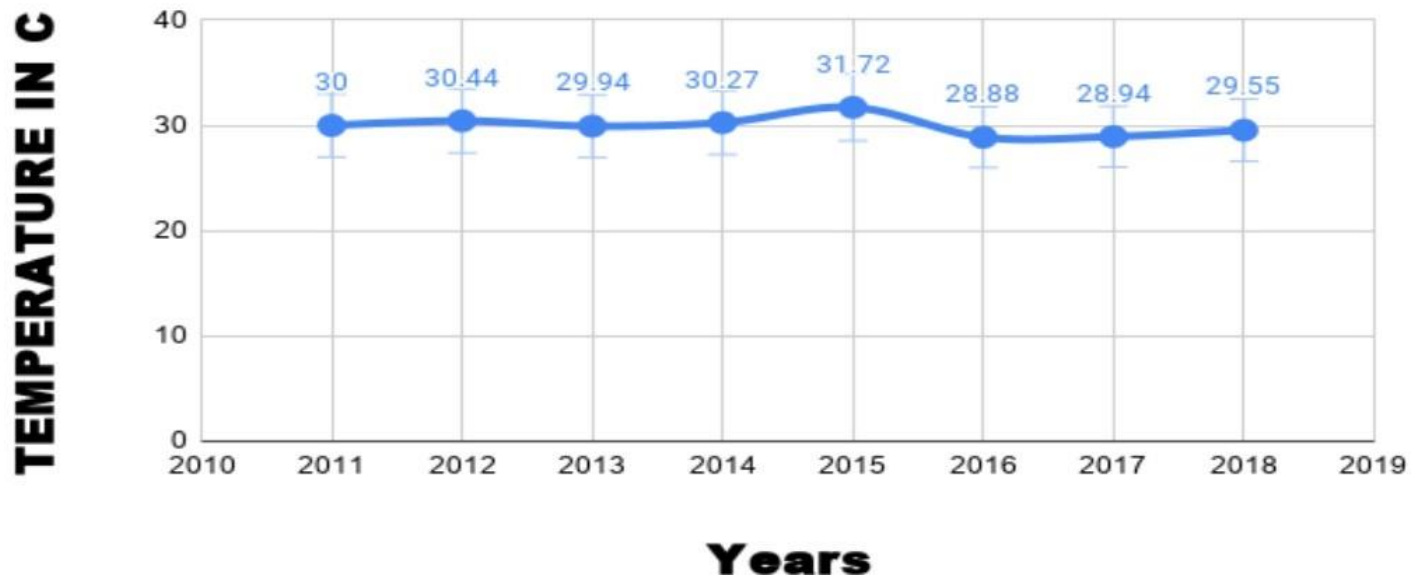


Fig : 5.24 September Temperature graph vs Years

October Temperature Data

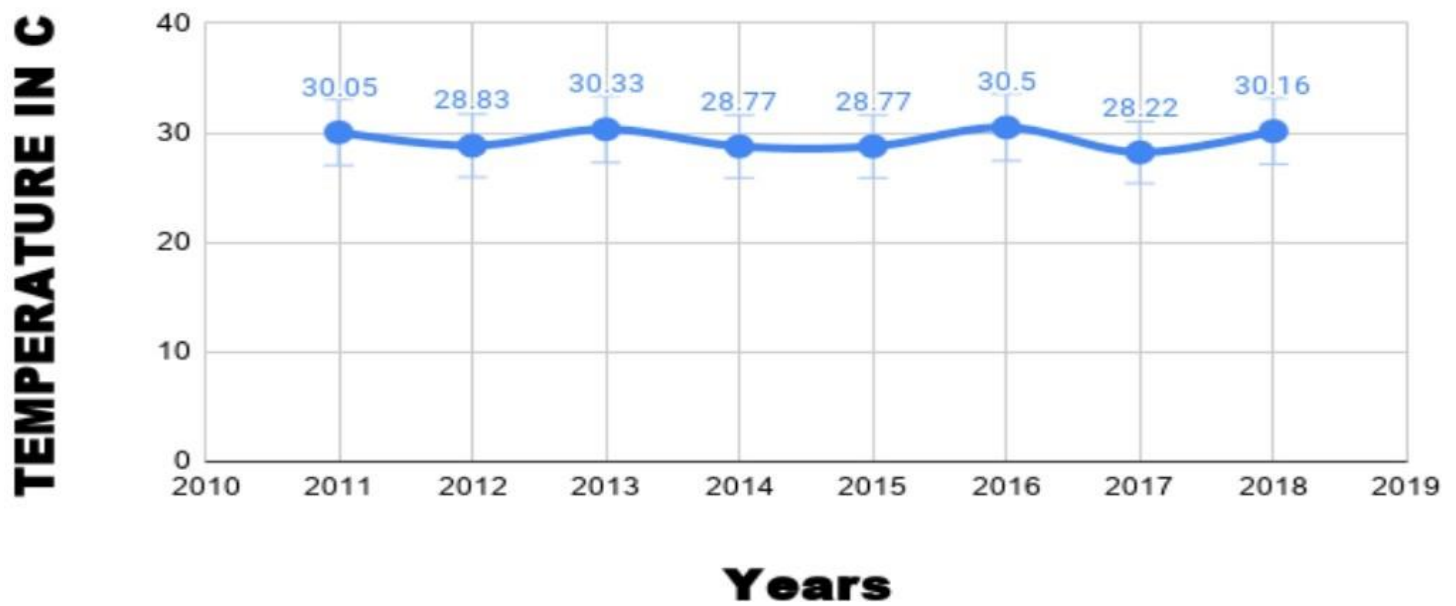


Fig : 5.25 October Temperature graph vs Years

November Temperature Data

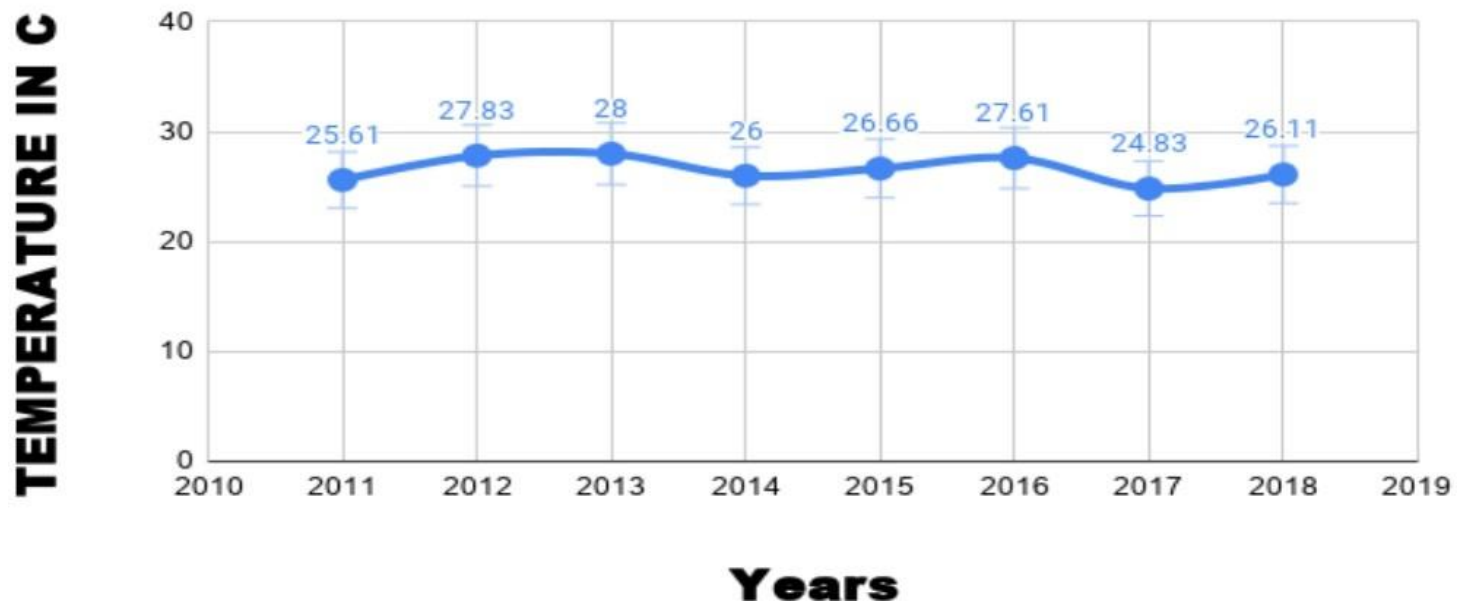


Fig : 5.26 November Temperature graph vs Years

December Temperature Data

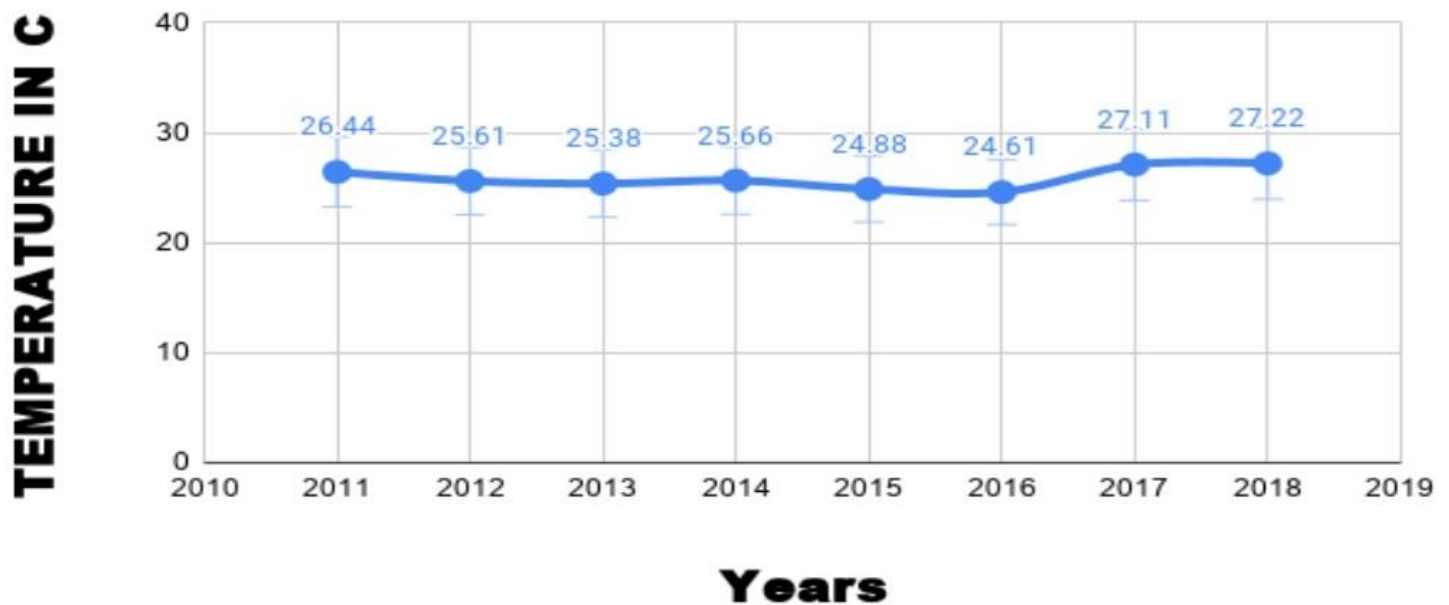


Fig : 5.27 December Temperature graph vs Years

5.5 RUNOFF CALCULATION

The basic hydrological details of the lake for the amount 2011 to 2018 are given in table 2. As are often seen, the inflow into the reservoir also because the discharge (to city water system scheme and if surplus any) from it varies widely – from 6 to 198 MCM respectively. The minimum storage in any given year within the lake varies from nil to maximum limit (94 MCM). the speed of evaporation from the lake varies from 0.10 cm/day leading to annual loss in lake storage up to 46 MCM. The lake surpluses only during 6 hydrological years during the above period..

Table 5.4 Runoff calculation of Our Study Area

YEAR	RAINFALL	INFLITRATION N	DISTANCE	TOTAL RUNOFF
2011-2012	136.6	121.51	95.61	21.59
2012-2013	98.2	76.53	53.21	17.48
2013-2014	100.6	85.34	62.85	20.27
2014-2015	105.2	76.35	54.6	23.44
2015-2016	244.7	196.32	179.3	46.74
2016-2017	70.9	54.3	23.87	26.83
2017-2018	161.1	83.25	20.4	29.87

5.6 RELATIONSHIP BETWEEN RAINFALL AND TEMPERATURE

Increase in temperature increases the evaporation and thus the moisture within the atmosphere increases which when reaches a sufficient level considering other parameters are okay, will cause rainfall.

The sea surface temperature is one among the important parameters for Cyclone. High sst, more chances of cyclone and rainfall

Low pressure causes convergence and lifting of airmass which cause rainfall. This low is made by heating.

Rise in Temperature with availability of moisture in most cases increases the rainfall

Precipitation is initiated by low / drop by temperature. Precipitation creates micro droplets. These micro droplets remain trapped in moisture clusters and keep floating. These droplets slowly fuse into each and still grow in size. Now they gain weight so can't float with moisture clusters. They drop downwards. The rain commences.

If the temperature remains high then there's no scope for precipitation. Another phenomenon is heat causes the air to expand. the recent air is relatively less dense or lighter than cold air. So it rises up within the sky. Cold air rushes in to occupy the space being vacated by hot air. This initiates wind cycle. just in case wind cycle is robust then it disperses the clouds within the vicinity. The clouds are pushed / dispersed away. therefore the chances of rain at that location goes down obviously it'll rain elsewhere . However, if the bottom is wet or there are warm bodies of water. Then the increase in temperature allows more water vapour within the air. Increased water vapour lowers the air density and it tends to rise. because the air moves higher it cools and if it cools enough will get localized shower or thunder storm, if a strong enough up draft occurs

5.7 RELATION BETWEEN RAINFALL AND RUNOFF

When rain falls, the primary drops of water are intercepted by the leaves and stems of the vegetation. this is often usually mentioned as interception storage. because the rain continues, water reaching the bottom surface infiltrates into the soil until it reaches a stage where the speed of rainfall (intensity) exceeds the infiltration capacity of the soil. Thereafter, surface puddles, ditches, and other depressions are filled (depression storage), after which runoff is generated. The infiltration capacity of the soil depends on its texture and structure, also as on the antecedent soil moisture content (previous rainfall or dry season). The initial capacity (of a dry soil) is high but, because the storm continues, it decreases until it reaches a gentle value termed as final infiltration rate.

The process of runoff generation continues as long because the rainfall intensity exceeds the particular infiltration capacity of the soil but it stops as soon because the rate of rainfall drops below the particular rate of infiltration. The rainfall runoff process is well described within the literature. Numerous papers on the topic are published and lots of computer simulations models are developed. of these models, however, require detailed knowledge of variety of things and initial boundary conditions during a catchment basin which in most cases aren't readily available.

For a far better understanding of the difficulties of accurately predicting the amount of runoff resulting from a rainfall event, the main factors which influence the rainfall-runoff process are described below. Fig: 5.6 explain the relation between the rainfall and runoff. From this we will conclude that, there's a relation between them. the height represents in Fig: 5.6 is maximum rainfall and maximum runoff i.e. in 2005.

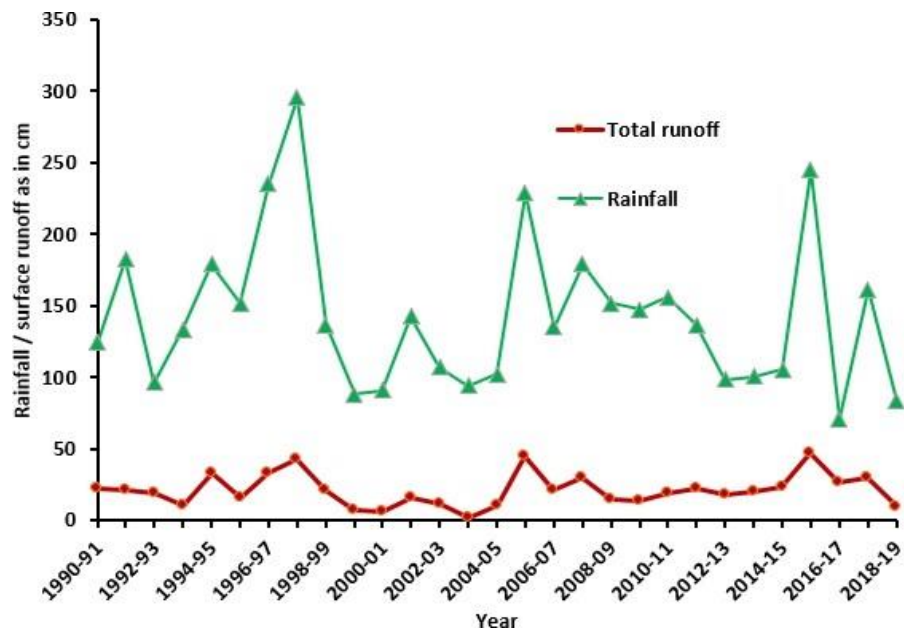


Fig. 5.28: Year wise runoff and rainfall

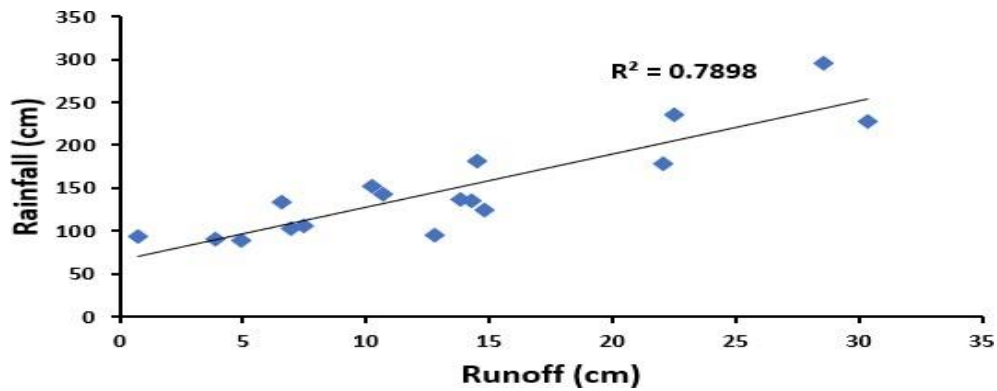


Fig. 5.29: Relation between Rainfall and Runoff

5.8 SIMULATION

At last our idea was simulated with the assistance of softwares namely sketchup and autodesk maps , autodesk autocad civil 3D , autodesk infraworks and its made into a video the snapshot of the above video is given below

Here our study area map is imported from google maps and therefore the red pipeline indicates the pipeline connecting the lakes and gray manhole chamber indicates the sensors chamber

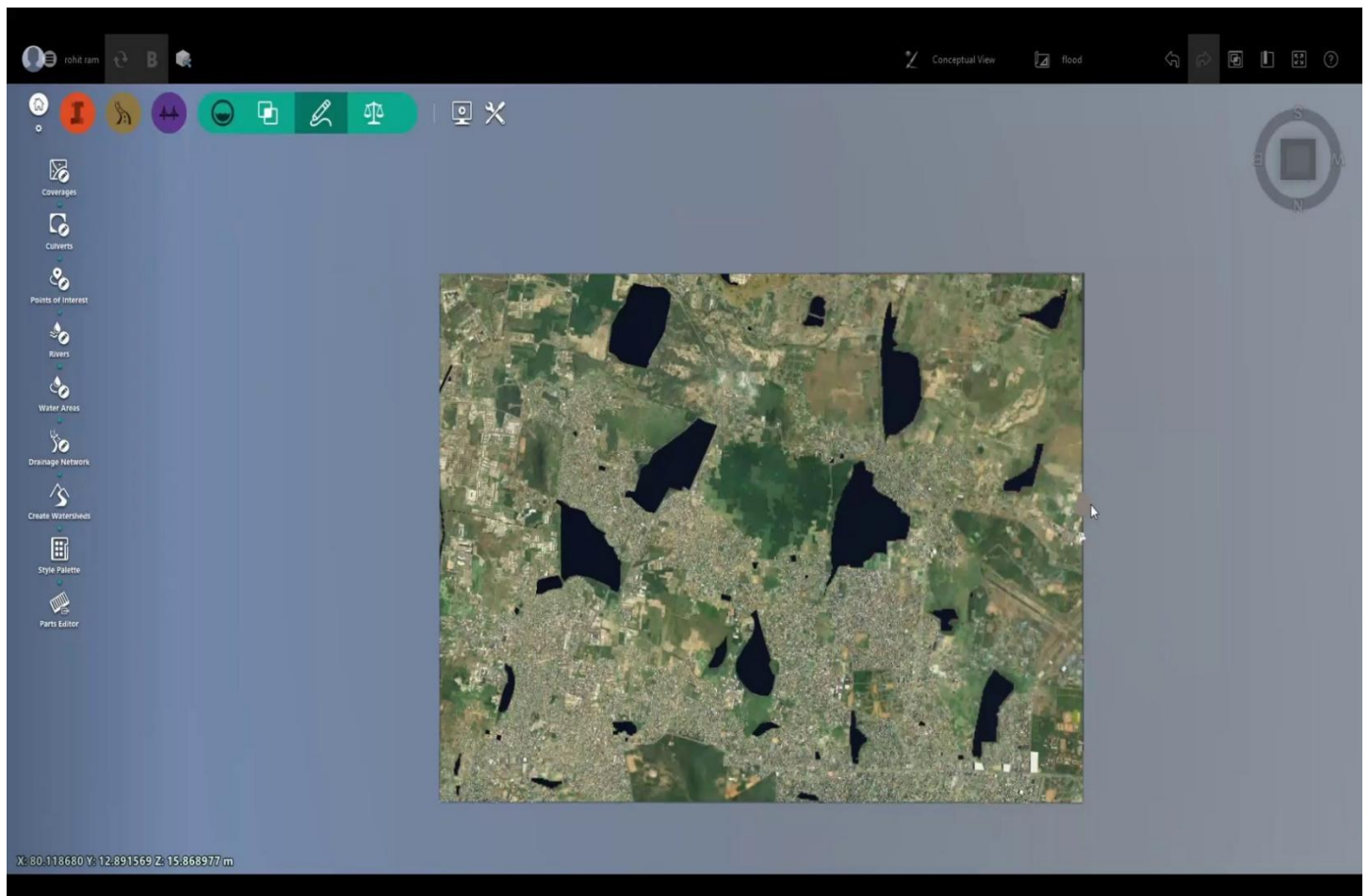


Fig 5.30 : Study map exported to INFRAWORKS from SKETCHUP

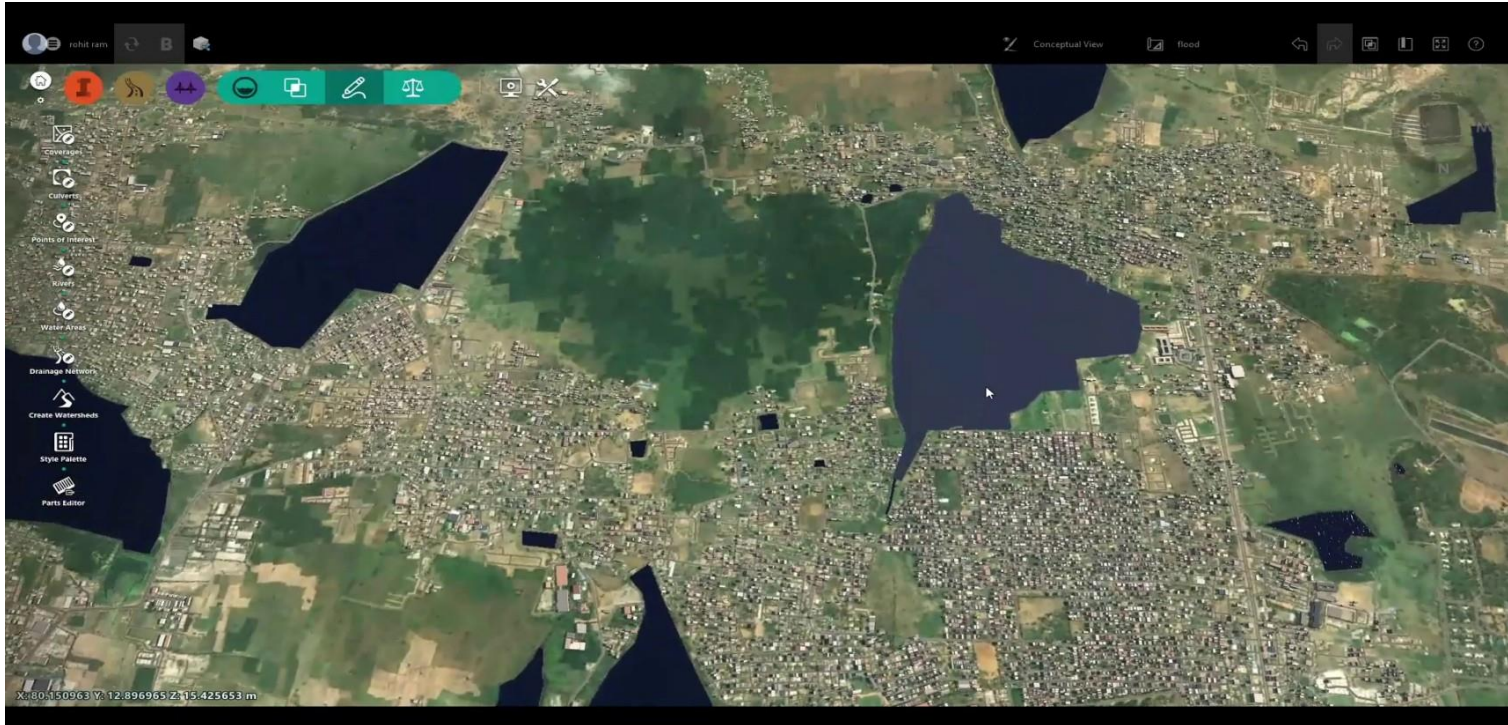


Fig 5.31 : Aerial view

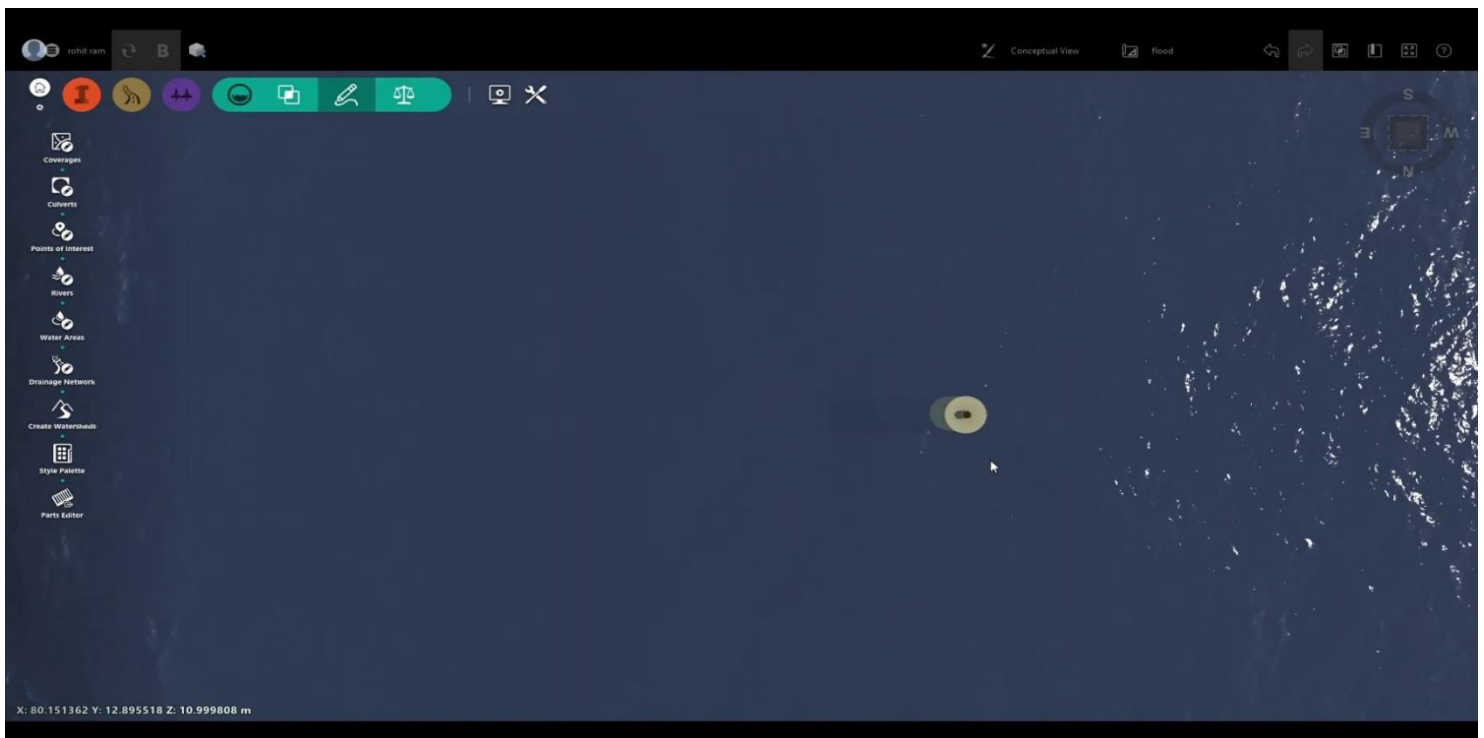


Fig 5.32 : Manhole chamber with sensors placement

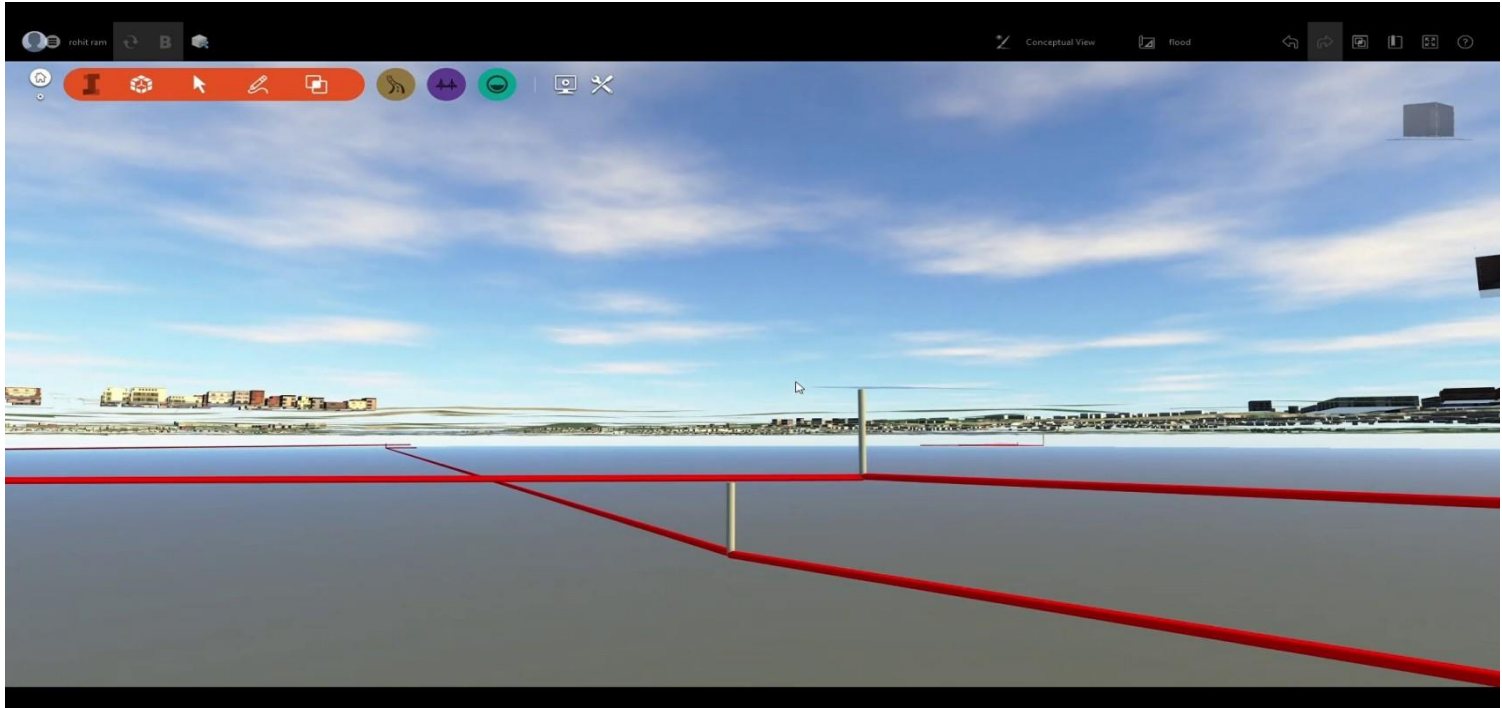


Fig 5.33 : Underground Pipeline Network

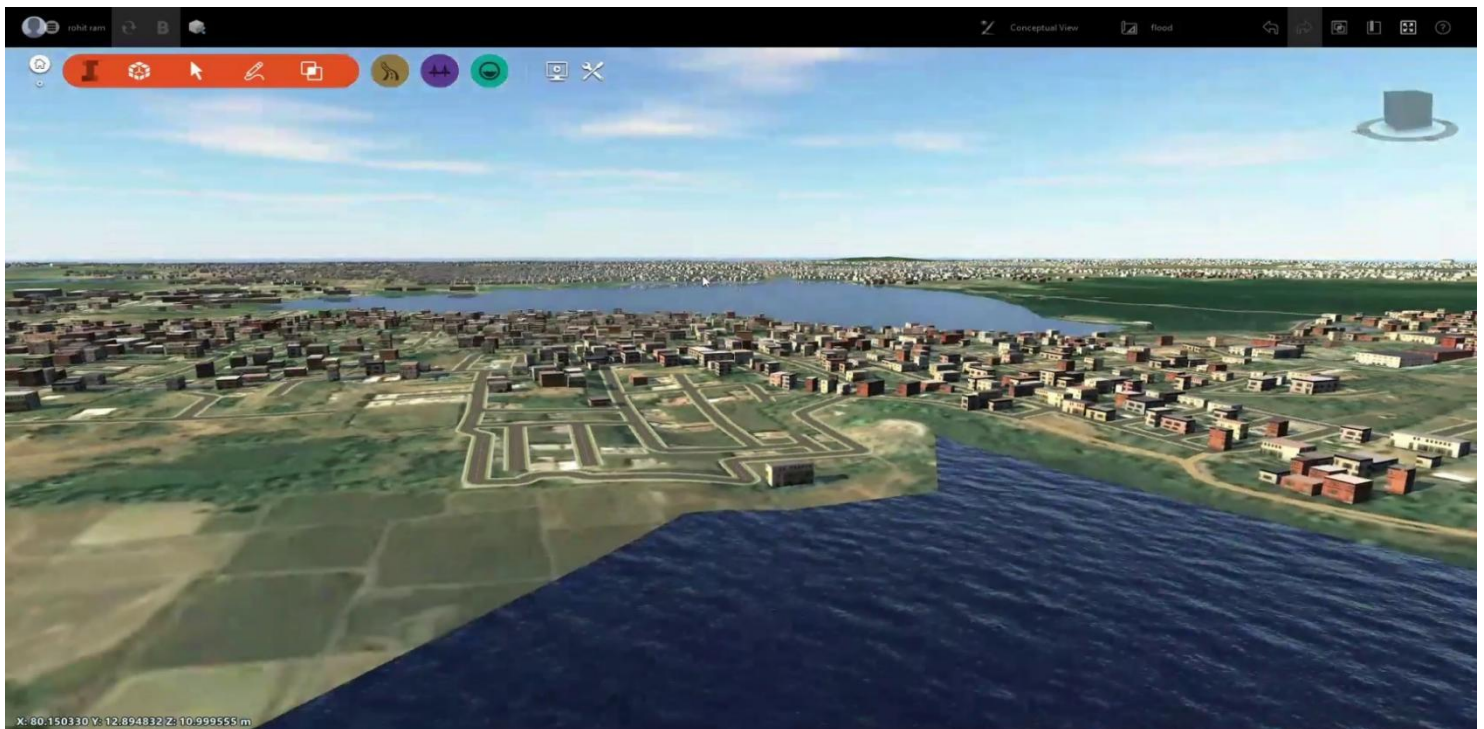


Fig 5.34 : Land Encroachment

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY AND CONCLUSION

- The average rainfall for the period is 97 mm. Residual mass curve shows the rainfall in the basin for the period 2011-2018. Year to year carryover of excess or deficiency in rainfall is best observed by the residual mass curve

From the rainfall pattern analysis 2015 - 2016 are the flood years and of the study area.

- Runoff into the reservoir and rainfall in the catchment area shows very good correlation ($r=0.9$)
- In the 8 years (2011- 2018) lot of area encroachment around the banks of lakes due to which there no room for extra rainwater
- Higher reservoir storage in the study area is dependent on rainfall amount and rainfall intensity
- Later this collected flood water can be used when needed
- With soil map and geomorphological map rainwater infiltration was calculated

REFERENCES

1. Pallavi Saxena, Abhishek Chandra, Abhinav Garg, Gaurav Sharma, Prateek Varma-" Conservation of ground water by artificial recharge in Delhi and Haryana states in India", Research gate, Vol-1/Issue-3, Pp 989-993, 2010.
2. G. Geetha, Prediction of monthly rainfall in Chennai using back propagation neural network model," International Journal of Engineering Science and Technology", Vol-3/ Issue-1, Pp 211-213, 2011.
3. Magnus U Igboekive & Adindu Ruth, Groundwater recharge through infiltration process- A Case study of Umudike south eastern Nigeria, Journal of Water Resources and Projection, Vol-3, Pp no 295-299, year-2011.
4. S. Sethuram" Watermanagent & issues in Chennai, India", Universal Journal of Environmental Research & Technology, Vol-4/Issue-6, Pp 299-306, 2014.
5. k Debu Mukherjee," A review of artificial recharge in India ", SSRG-IJCE, International Journal of Civil Engineering, Vol-3/Issue-1, pp 57, 2016.
6. T. Subramani et al, Water resources planning & implementation for Chennai metro water using GIS., International Journal of Engineering Trends &Technology in Computer science (IJETTCS), Vol-6/issue-3, Pg. no 126-137, 2017.
7. Dr. A. S. kanagalakshmi Gokul Sudharsan P, Ranjith R, Mohammed Saleem Badhusa N, Sanjay Krishnan, Experimental analysis of impact of quality and quantity of water bodies in Chennai., IOSR-JMCE, Journals of Mechanical and Civil Engineering.Vol-14/Issue-2, Pp1-8, 2017

8. N. Ramsundram & Nisha khanam," Impact of climate change on reservoir Inflow prediction- A case study" IJRTE -International Journal of Recent Technology &Engineering, Vol-7/Issue -4s, Pp 132, 2018.
 9. Khan Mohammad Takal, Abdul Rahman sorgul, Abdul Tawab, Balakar zai," Estimation of Reservoir Storage Capacity and Maximum Potential Head for Hydro-Power Generation of Propose Gizab Reservoir, Afghanistan, Using Mass Curve Method", International Journal of Advanced Engineering Research and Science (IJAERS)
11. [Vol-4, Issue-11], Pp 98-104, Nov- 2017.
 10. Eric Muala, Yasir A. Mohamed, Zheng Duan, Pieter van der Zaag
 11. " Estimation of Reservoir Discharges from Lake Nasser and Roseries Reservoir in the Nile Basin Using Satellite Altimetry and Imagery Data", Remote sensing, Vol-6, Pp 7522-7545, 2014
 12. Reservoirs are the major source of the city's water supply and hence understanding the factors affecting storage.
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