RAINFALL VARIATION AND FREQUENCY ANALYSIS STUDY IN NAMAKKAL DISTRIC TAMILNADU

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ABSTRACT

The aim of this project is to give a complete study of Ten years (2009-2018) daily rainfall data for Namakkal district was collected from the TWAD (Tamil Nadu Water Supply and Drainage Board) to analyse the nature of distribution and frequency of rainfall. The report includes the objectives of the work. Average annual rainfall for 10 years data was collected as 938.1 mm and average annual rainy days were 45.9 maximum monthly rainfall (197.58 mm) was received during the month of September which was mostly by southwest monsoon. Maximum rainy days were in October (8.6 days). The rainfall received during the winter, summer, southwest and northeast monsoon seasons were 10.5, 181.0, 453.5, 293.0 mm, respectively. Rainfall frequency analysis done by Weibull’s method revealed that the annual average rainfall of 938.1 mm can be expected to occur once in 2.5 years at a probability of 40%. Monthly dependable rainfall (p>75%) is expected to occur in every year during the months from September to October. Climatic factor plays a major role in Indian agriculture in that rainfall play a key role. Being rainfall is the important factor for agriculture normally has to rely on secondary data. The study area taken for this analysis is Namakkal district of Tamil Nadu The extent of the area is extends between 11°00’ to 11°36’10” north Latitudes and 77°40’ to 78°30’00” east longitudes. It is purely a semi arid region and agriculture normally depends on seasonal characteristics of rainfall. This study seeks to understand the rainfall behavior of the study area. The rainfall data used for this analysis is from 2004 – 2018. In this analysis rainfall variability has been calculated to find out the dependability of rainfall over the study area. From the analysis it is to be identified that Paramathy location has more than 50% of CV in both the monsoon season. To understand the long term changes in rainfall trend analysis has also been studied over the area. It is a powerful tool for representation and analysis of spatial information related to rainfall analysis.

Keywords: Climate, Variability, Monsoon, Trend.

INTRODUTION

1.1 GENERAL

Rainfall, being considered as the prime input for agriculture has its own erratic behavior in terms of amount and distribution. For better crop planning, a detailed study on rainfall behavior is vital. Rainfall variability, both in time and space influences the agricultural productivity and sustainability of a region. Rainfall analysis for crop planning was carried out in different regions of the country as reported. The annual and seasonal rainfall received and its variability directly influences the success or failure of crops through its beneficial or adverse effect their growth and yield. Therefore, the study of variability of annual and seasonal rainfall is essential in selection of suitable crops and to take appropriate mitigating measures based on rainfall characteristics. Agriculture being mainly rainfed in Namakkal region of Tamil Nadu state is characterized by uneven and erratic distribution of rainfall. Since rainfall is the only source of moisture, the spatio-temporal distribution of rains holds the key in determining the fate of entire crop productivity in the region. There are so many authors studied about the rainfall variability, Krishnakumar and Prasad Rao (2008) reported rainfall variability in Gujarat and Kerala state respectively. Halikatti et al. (2010) reported annual and seasonal rainfall variability at Dharwad, Karnataka. A similar attempt was made to analyze the rainfall distribution pattern in monthly, seasonally and annually for Raichur region.

The district is divided into two Revenue Divisions: Namakkal and Thiruchengode, with five Taluks earlier namely Namakkal, Thiruchengode, Rasipuram, Paramathi and Kollihills. Sendamangalamhas been announced as a new Taluk with 30 Revenue firkas. The district has five Municipalities, 15 Panchayat Unions (Blocks), 19 Town Panchayats and 322 Village Panchayats. The Northern portion of Namakkal is mountainous and the southern areas are plains. The chief rivers that run through the district are Cauvery, Aiyaru, KaripottanAaru and Thirumanimutharu. The river Cauvery flows south and south west traversing across the border. It is one of the major water sources for over all socio economic progress of the district. Geography

Namakkal District comes under the north western agro climatic zone of Tamil Nadu. It was bifurcated from Salem District and has been functioning as a separate district since 01-01-1997.

It is bounded by Salem in the north,Karur in the south,Trichy in the east and Erode in the west. The Geographical area of the district is 3363.35 square km. Geography of the district is vast and it possesses several hilly regions. The district is situated at an altitude of three hundred meters above the MSL (mean sea level). The Kumarapalayam channel runs for 10.7 km covering the land area of 1032.59 hectares. Thirumanimutharu River starts from Salem district up to Namakkal for the coverage of total area of 18,621 hectares by 105km long length of distance. It benefits the lands in Namakkal district by 34.44 per cent only. The Karattaru begins at Kollihills runs up to Trichy district covering a distance of 41km and irrigating 8318.05 hectares. Topography

It is placed in the dividing portion of two watersheds between the Kaveri and the Vellar System with the taluks of Attur, Rasipuram and Namakkal on the East and Salem, Omalur and Mettur on the West. The Kolli hills in Namakkal and few isolated hills and ridges scattered over Namakkal, Rasipuram and Tiruchengode along with the Valleys and rolling topography contributes to the beautiful physiography of the Namakkal district.

The northern regions of the district of Namakkal are mountains and the southern areas are plains. The plain area of this district can be divided into three elevating stages. The lower elevation (which is below one hundred and fifty meters) has Namakkal and Paramathytaluks which are benefited by the Kaveri River. The mid-elevation (which is from one hundred fifty to three hundred meters above the mean sea level) occupies the major area in all taluks. The high elevation area (which is between three hundred to six hundred meters) spreads over mainly in Rasipuram and Namakkaltaluks. The major rivers running through the Namakkal district in Tamil Nadu are Cauveri, Karipottamaru and Thirumanimuthar. Soil Condition The soil of Namakkal district can be broadly classified into 5 major soils types viz., Red Soil, Black Soil, Brown soil, Alluvial and Mixed Soil. Major part of the district covered by Red Soil. Black soils are mostly seen in Namakkaltaluk. Brown Soil occupies only a small portion of Tiruchengodetaluk and the Alluvial Soil is seen along the river courses in Namakkal, Paramathi and Tiruchengodetaluks.

Mixed soil is the second major soil type occurring all the taluks of the districts. Climate.The district enjoys a tropical climate. The weather is pleasant during the period from November to January. The normal rain fall occurs during North East monsoon and moderate rainfall is received during South West monsoon. Human Development Status.HDI Blockwise indicates the top three ranks holding blocks as ThiruchengodeNamakkaland Rasipuram. Kollihills block has been placed in the lowest position of three indices.. Literacy rate is very low compared to other blocks. Most of the people are marginal farmers engaged in agriculture activities only. The basic amenities are very poor particularly, facilities of fuel, toilet, house and electricity. In terms of health aspect, the IMR, MMR and U5MR was also poor. Pallipalayam block is placed first for having lowest gender inequality in the district. This block is covered by the strong mixture of industry and agriculture situated on the bank of

Cauvery and very near to the adjoining district of Erode. Erumapatty block is placed in the second position of top three due to high female literacy rate and as female participation.

In the electoral roll was found to be very high at the same time and the agricultural wage rate did not have any huge variation. Mallasamuthiram was placed in a lower rank in GII due to MMR being high, low level of literacy, low female participation in empowerment and work participation in non-Agriculture and vast variation in agricultural wage rate. In CDI, the top level blocks – Pallipalayam, Mohanur and Tiruchengode fared well in the dimensions of health and education. At the sametime, in the bottom level, blocks other than Kollihills, (except U5MR) all other indicators of health and education were found to be enhanced in Vennandur and Puduchathiram except U5MR. The Multidimensional Poverty Index indicated that the highest number of poor people were in the blocks of Kollihills, Senthamagalam and Namagiripet located as a contiguous block. Employment, Income and Poverty.

REVIEW OF LITRATURE

2.1 LITRATURE REVIEW

Ramasamyetal(1999) have analysed the monthly and annual rainfall data of Coimbatore district for the period from 1971-72 to 1993-94. This analysis shows that the rainfall is just normal and below from 1980-81 to 1993-94. Hence the rainfall of this nature might not contribute to augment groundwater potential.

In the same way, Singh et al(2004) have made an attempt to understand the performance of monthly rainfall for June, July, August and September when the seasonal rainfall is reported to be excess, deficient or normal by using historical data series of 30 years (1970-99) of monthly and seasonal rainfall. All the locations receive excess or normal rainfall in monsoon season when individual month receives excess rainfall in the entire subdivision. From the probability analysis, it is seen that there is a rare possibility of occurrence of seasonal rainfall to be excess/deficient when the monthly rainfall of any month is deficient/excess in the entire subdivision.

Prediction of groundwater levels has significant applications in water resource utilization and management. The purpose of observation of groundwater lies primarily in studying its temporal and spatial changes. Statistical approaches are becoming increasingly useful for the evaluation of groundwater regimes. Rockaway &Johnson (1977) have indicated that the application of trend analysis to groundwater studies is based on the assumption that the water table could be approximated by a mathematically computed polynomial of water levels of the wells in the aquifer.

Marechaletal(2002) have observed the short-interval water levels in a deep well in an unconfined crystalline rock aquifer. The observed values show cyclic fluctuation in the water levels and principal trend due to rainfall recharge. Spectral analysis is carried out to evaluate the correlation of the cyclic fluctuation to the synthetic earth tides as well as groundwater withdrawal time series in the surrounding area. It is found that the fluctuations have considerably high correlation with earth tides, whereas groundwater pumping does not show any significant correlation with water table fluctuations. It is concluded that the earth tides cause fluctuations in the water table and unconfined aquifer is characterized by a low porosity.

The conventional method of estimating recharges is used by Penman(1948) andGrindley(1967). Recharge is viewed as a function of effective rainfall, precipitation minus evaporation, which is distributed according to a simple land use model.

Farrington &Bartle (1988) have evaluated water balances of Banskia woodland on coastal deep sands of Southwestern Australia in detail. Estimation of groundwater recharge using the water balance approach shows considerable variation in water levels over the years. Recharge highly correlates with the annual rises in groundwater table and the rainfall received during winter and spring seasons. A long-term estimates of groundwater recharge at the site, using the chloride balance, is similar to the average value obtained using the water balance method.

Dharaetal(1994) have taken a practicable approach for recharge estimation from rainfall and soil parameters in lower deltaic region of Ganges, originating from the Himalayan region of India. Infiltration rate, rainfall and evaporation dataare being collected continuously for a period of 140 days from

1st June to 18th October for the year 1990. Recharge is estimated by three empirical formulae on the basis of rainfall. It is also estimated on a modified concept of prolonged infiltration rate after 36 hours of saturation of soil that seems to be a better method as it is found that the total amount of infiltrated water is 77.29 m, which has potential recharge under continuous water supply.

Similarly, Jayakumar & Ramasamy (1995) have conducted a study on groundwater in the Attur village of Salem district in Tamil Nadu. Fifty wells are identified and their well yield data are derived from pumping tests. Rainfall data of 35 years are collected and extrapolated to 50 well locations by kriging method. The well yield data are taken as the dependent variable and rainfall data are taken as the independent variable and bivariate and third degree polynomial regression analyses are carried out. From such analyses, a model is developed, which is capable of predicting well yield from rainfall data. The predicted and observed yields are compared. The variations are restricted within 20% of the original values; hence the model could be accepted.

The monsoon rain recharges mainly hard rock aquifers in the rain-fed areas of India. The water table is at its lowest level in the beginning of the monsoon (May-June),it rises as the monsoon progresses, attains its highest level at the end of the monsoon (October-November) and recedes thereafter during the non-monsoon period. Since the groundwater levels in hard rock aquifers determine the amount of water available from dug wells, simulation of the response of the groundwater level to rainfall is a necessary part of Dug Well Irrigation Management (DWIM).

The reaction of groundwater depends on many factors including storage coefficient, transmissibility, thickness, shape and areal extent of the aquifer, initial groundwater level, intensity and distribution of rainfall, drainage pattern of the watershed, vegetation and the water withdrawal pattern for human and other uses. Therefore the recharge rate of any unconfined aquifer is both “site specific” (Rennollset al 1980, Viswanathan1983) and “time specific” (Viswanathan 1984).

2.2 GENERAL

Water is a precious and renewable resource on the earth. Most of the people depend upon the rainfall for agricultural production. The demand for clean water is increasing nowadays due to the decrease in the rainfall and the deterioration of the surface water quality due to the discharge of industrial effluent and domestic sewage. The study of rainfall pattern and the availability of groundwater are important for planning the use of available water for drinking and agriculture purposes. The variability of rainfall and the pattern of precipitationplay a major role in developing the economy of the country. The total rainfall received in a given period at a location is highly varying from one year to another. The variation in the rainfall is due to the climate of the place. Geologically, the study area enjoys a tropical climate. The pleasant weather occurs in the month of November to January and cools down progressively from the middle of June. The mean daily maximumtemperature drops to 30.2°C while the mean dailyminimum drops to 19.2°C and 19.6ºC in January. The annual maximum and minimum temperature is 33.5ºC and 17.8ºC. The study areareceives the rainfall under theinfluence of both southwest and northeast monsoons. The northeast monsoon chiefly contributes to therainfall in the district.Hydro-meteorological study is helpful to assess the causes for the water quality deterioration. The rainfall data collected from the Tamil Nadu Water and Drainage (TWAD) board and Public Works Department (PWD) is used for the hydro meteorological analysis of the study area.

2.3 ANALYSIS OF RAINFALL

Rainfall from in and around the study area from fifteen rain gauge stations is taken to assess the total rainfall. The latitude and the longitude of the rain gauge station locations are presented in Table 2.1. The geographic allocations of the rain gauge stations are shown in Figure 2.1.

Table 2.1 Locations of the rain gauge stations

Rain gauge stations	Latitude	Longitude
NAMAKKAL	11°45'74"	78°18'12"
ERUMAIPATTI	11°35'55"	78°19'20"
MOHANOOR	11°05'99"	78°14'22"
PUDUCHATRAM	11°38'67"	78°16'23"
SENTHAMANGALAM	11°28'20"	78°23'48"
MANGALAPURAM	8°62'67"	76°84'61"
RASIPURAM	11°48'27"	77°48'01"
TIRUCHENGODE	11°37'82"	77°89'69"
KUMARAPALAYAM	11°26'47"	77°41'39"
PARAMATHY	11°15'25"	78°02'52"

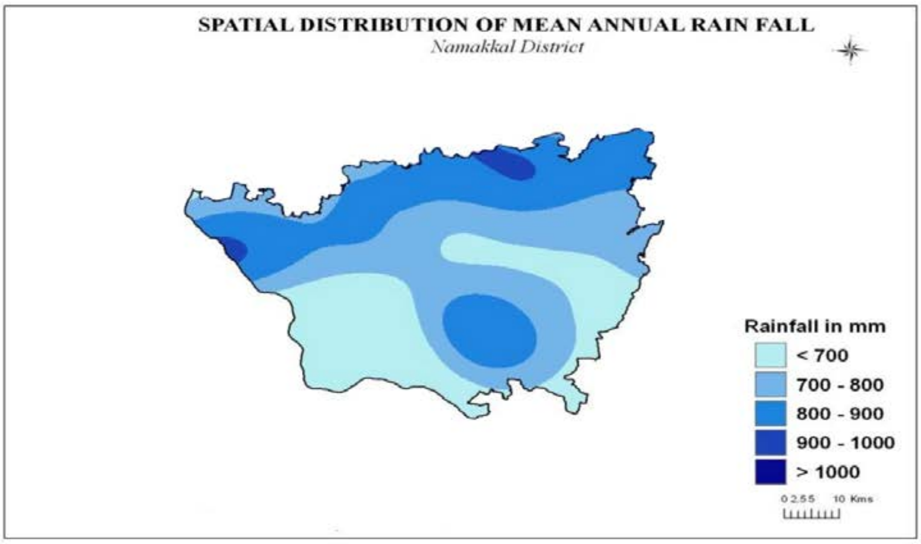


Figure 2.1 Location of rain gauge stations

For the present study, rainfall data from 2004 to 2018 (one decade) are considered. Table 2.2 and Figure 2.2 give the annual and average rainfall for various rain gauge stations.

The highest rainfall of 1491.8mm on Sendamangalam in the year 2012. Most of the rain gauge stations received highest rainfall in the year 2011. In Namakkal district, At Puduchatram 864mm, erumaipatti 720.6mm, Mohanoor 783.2mm, Rasipuram 968.9mm and Mangalapuram 955.9mm, Tiruchengode 717.8mm, Kumarapalayam983.4mm received higher average rainfall as compared to anormal rainfall of 680 mm. The average rainfall observed in all the rain gauge stations during 2004 to 2018 for postmonsoon, premonsoon, southwest monsoon and northeast monsoonare given in Table 2.3

Table 2.2 Annual and average rainfall from rain gauge stations

Rain gauge stations		Rainfall (mm)								
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Namakkal	794.30	1491.60	711.90	678.00	997.50	537.00	982.50	835.53	502.00	514.50
Sendamangalam	659.5	983.8	1165.8	843.5	589.3	776.5	1161.2	909.8	1491.8	808.9
Puduchatram	743	559.2	468.5	864.9	720.6	657.9	864	775.4	801.6	386.3
Erumaipatti	683.2	482.5	576.2	548.9	602.8	458.4	498	651.71	720.6	433.1
Mohanoor	785.3	521.2	794.3	711.9	531	762.1	408.4	817.7	783.2	268.99
Rasipuram	621.3	862.5	717.8	585	775.4	627.8	968.4	714.2	588.5	385.5
Mangalapuram	909.8	523.8	385.5	268.9	199.7	784.3	955.9	773.5	337.7	271.5
Tiruchrngode	694.4	590.9	573.1	401.9	720.6	698.8	717.8	632.2	314.9	209.9
Kumarapalayam	968.4	1010.5	846.2	932.5	678.9	732.9	983.4	899.9	316.4	222.7
Paramathy	621.3	444.7	314.9	585	404.4	703.0	691.6	552.7	282	498.6

Rain gauge stations		Rainfall (mm)			
	2014	2015	2016	2017	2018
Namakkal	654.85	731.00	324.00	911.00	581.30
Sendamangalam	616.8	1002.6	450	709.6	715.8
Puduchatram	589.2	495.1	352.1	583.7	506.9
Erumaipatti	416.8	356.6	392	545.2	697
Mohanoor	523.8	404.4	573	692.7	199.7
Rasipuram	579.6	755.9	621.3	640.2	544.4
Mangalapuram	335.76	585	368.5	862.5	596
Tiruchrngode	348.7	232.9	237.5	554.9	668.6
Kumarapalayam	645.2	444.7	431	604.7	405.1
Paramathy	380.3	354.1	399	455.4	312.2

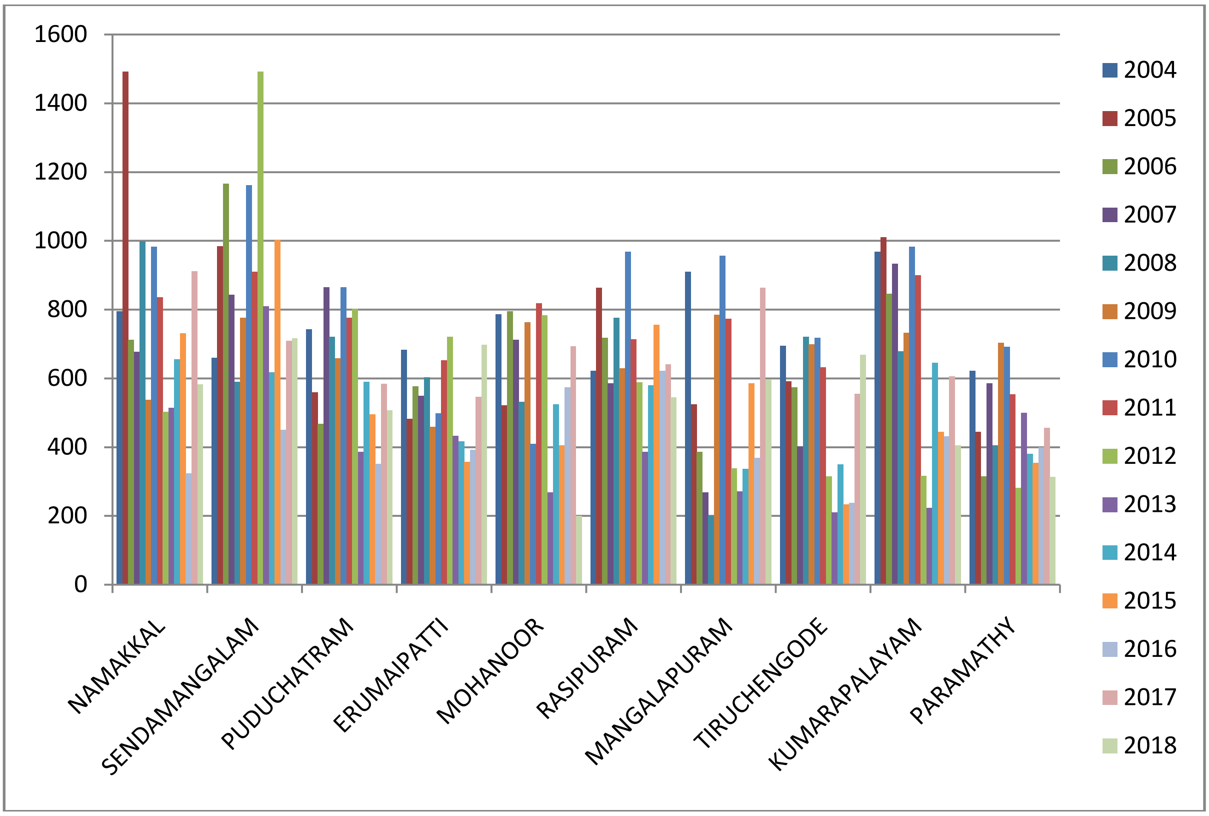
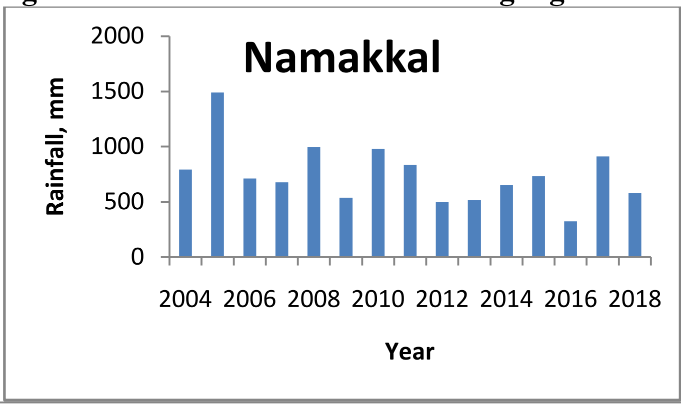
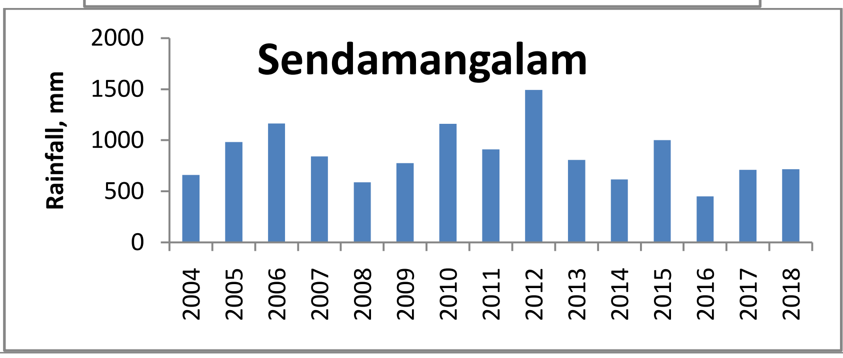
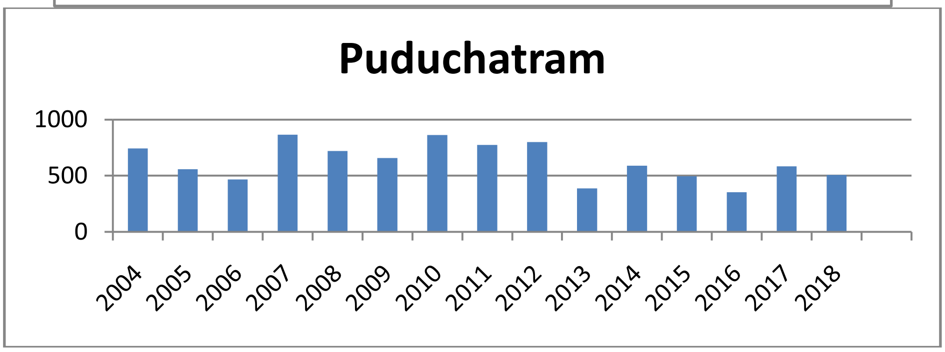
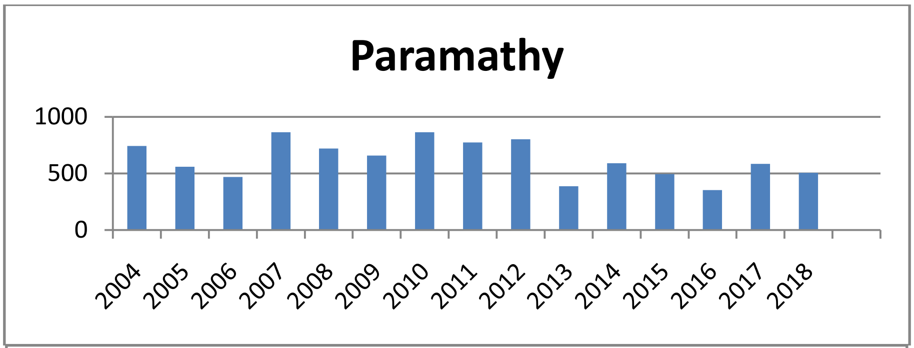


Figure 2.2 Annual rainfall from rain gauge stations





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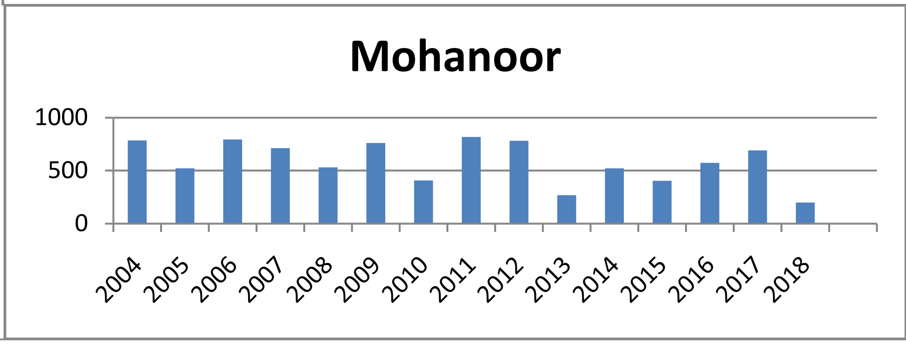
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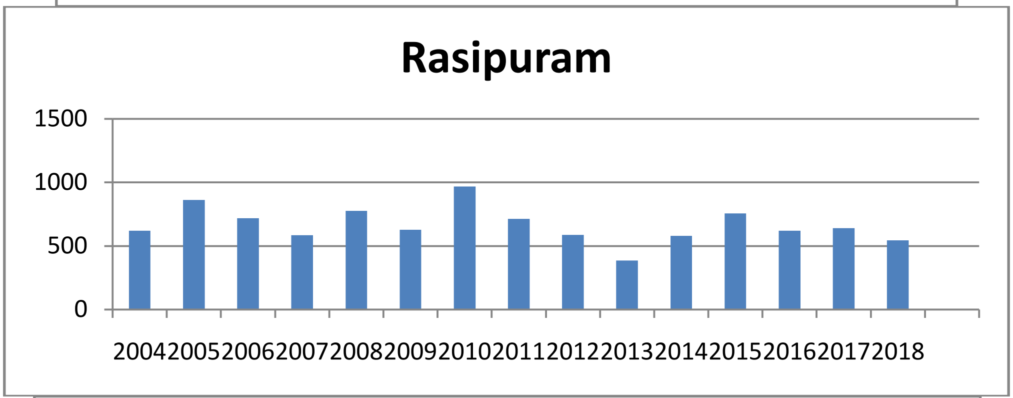
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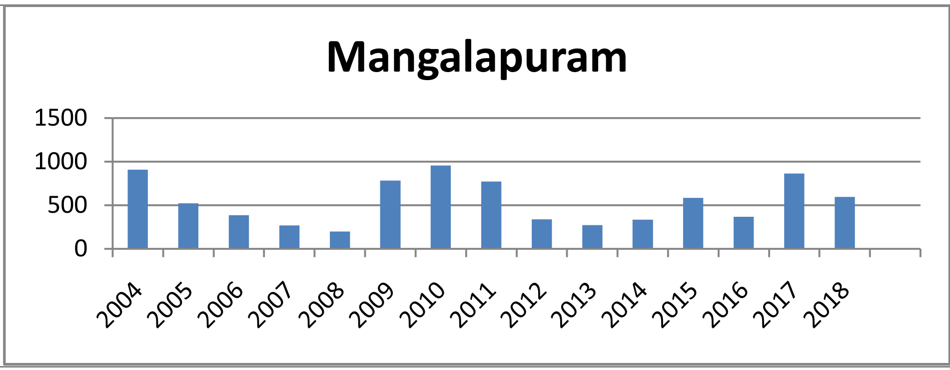
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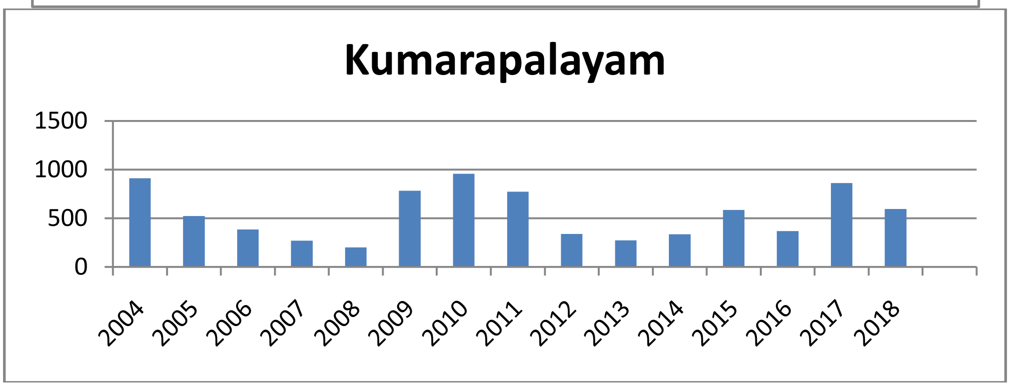
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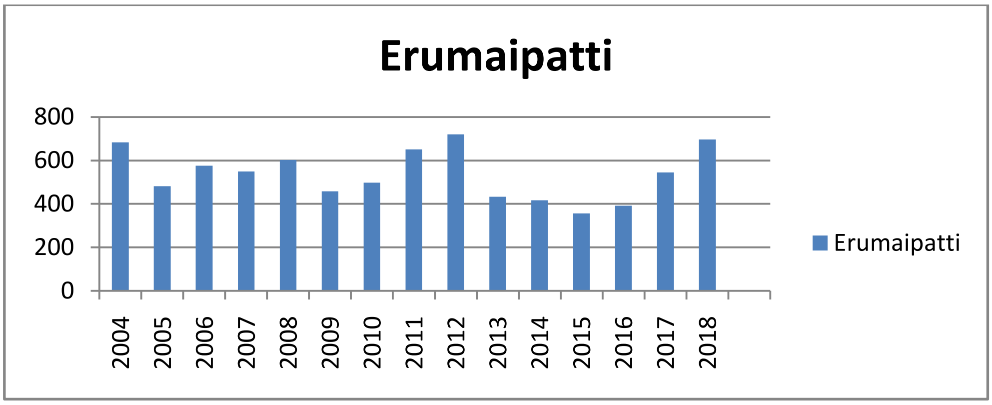

Table 2.3 Average rainfall from all the rain gauge stations for different seasons

Seasons	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Postmonsoon	o	7	21.67	0	30.3	0.66	0	7.67	1	4.33
Premonsoon	96.5	25.2	50.25	25.25	46.75	16.75	55	53	34.5	14.5
Southwest monsoon	21	21.3	154.47	109.5	95.5	205.5	81	22.0	42	33.49
Northeast monsoon	122.33	181	112.33	119.3	176.33	88.67	110	146.67	106.33	120.67

Seasons	2014	2015	2016	2017	2018
Postmonsoon	**0**	9.33	0	**3**	**7**
Premonsoon	55.5	54.25	46.25	40.5	36.25
Southwest monsoon	33.49	79.5	67	84	24.75
Northeast monsoon	122.67	109.33	34.4	190.67	121.97

2.3.1 Average Rainfall during Postmonsoon Season

The average rainfall during the postmonsoon season is presented in Figure 5.3. During postmonsoon season, the region received the highest average rainfall of 30.mm during the year 2008 and it had no rainfall during the year 2004 and 2018.

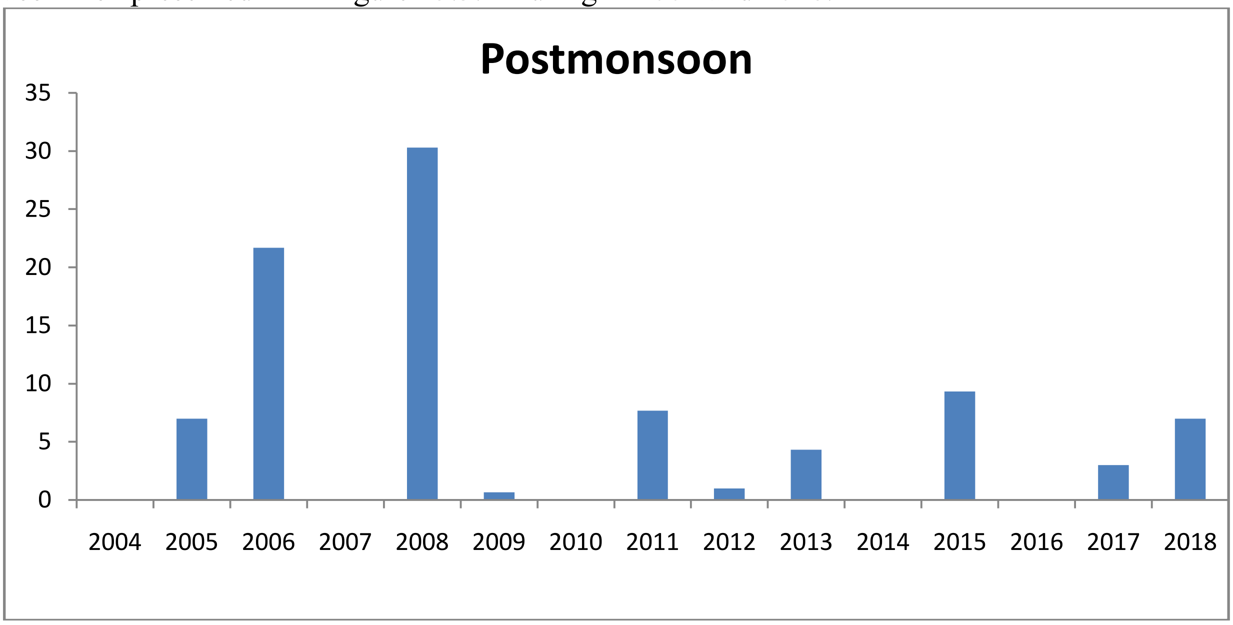

Figure 2.3 Average rainfall during postmonsoon season

2.3.2 Average Rainfall during Premonsoon Season

The average rainfall during the premonsoon season is presented in Figure 5.4. During premonsoon season, the region received the highest average rainfall of 96.5mm during the year 2004 and the lowest average rainfall of 14.5mm was recorded during the year.

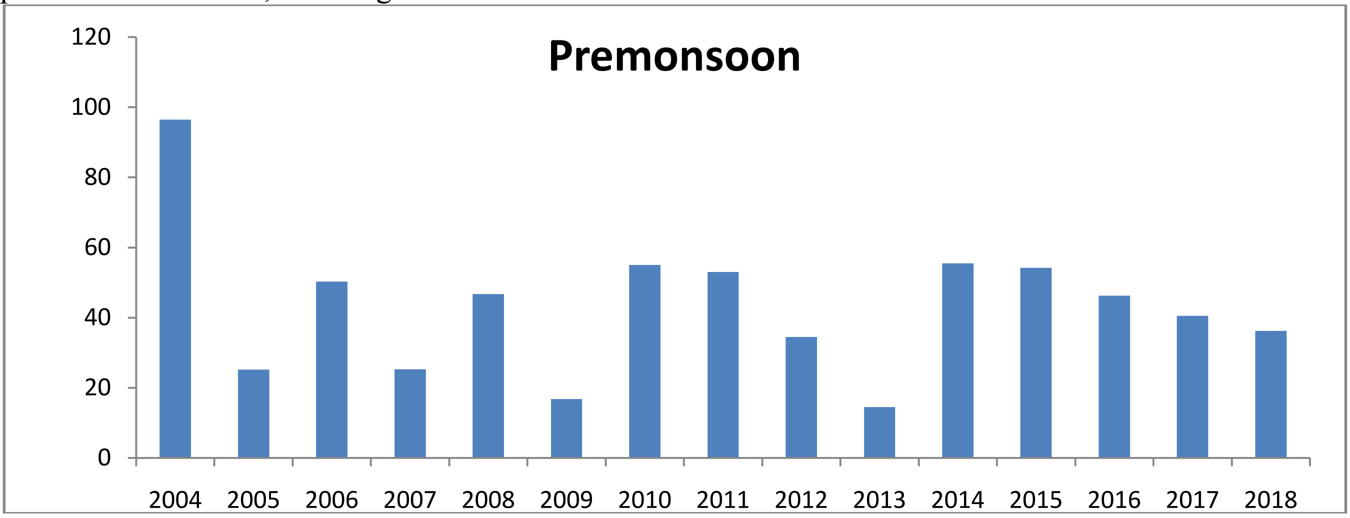

Figure 2.4 Average rainfall during premonsoon season

2.3.3 Average Rainfall during Southwest Monsoon Season

The average rainfall during the southwest monsoon season is presented in Figure 5.5. During southwest monsoon season, the region received the highest average rainfall of 205.5mm during the year 2009 and the lowest average rainfall of 21mm was recorded during the year 2004.

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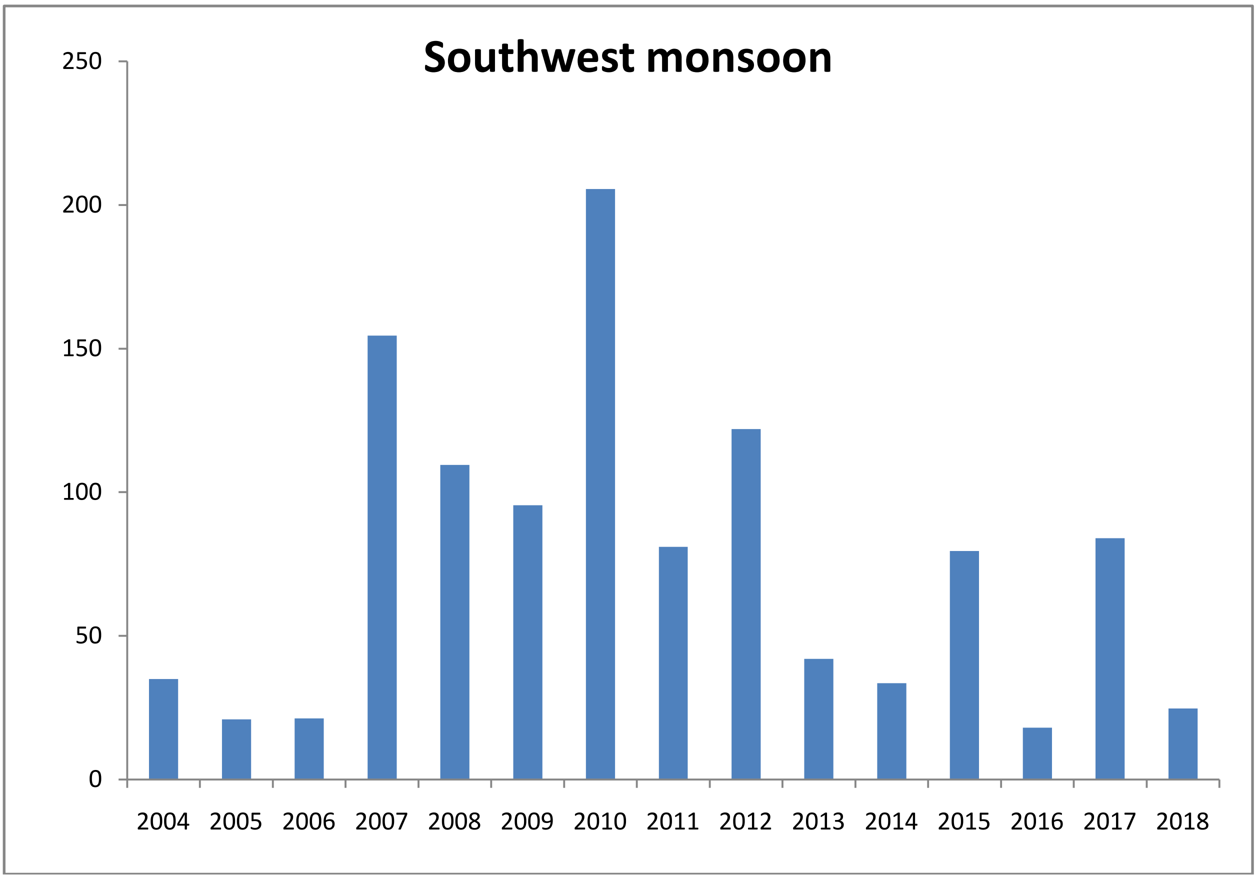

Figure 2.5 Average rain fall during south west monsoon season

2.3.4 Average Rainfall during Northeast Monsoon Season

The northeast monsoon season is an important rainy season. The average rainfall during the northeast monsoon season is presented in Figure 5.6. During northeast monsoon season, the region received the highest average rainfall of 190.67mm during the year 2017 and the lowest average rainfall of 34.7mm was noticed during the year 2016.

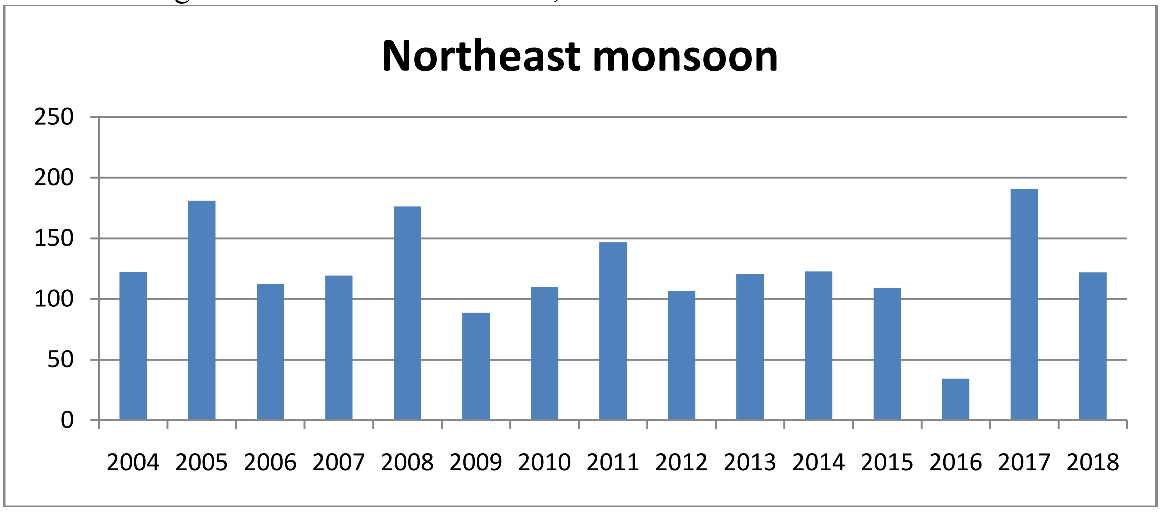

Figure 2.6 Average rainfall during northeast monsoon season

Data and analysis:

There are thirty seven rainfall stations selected for the present study. The daily rainfall data for the period of 1980 – 2010 have been collected for major stations and available rainfall stations which are installed in last five years. The daily rainfall data has been tabulated as monthly for the respective rain gauge stations. The tabulated data are analyzed to calculate mean rainfall, coefficient of variation, precipitation ratio and frequency. The results are mapped in GIS environment by applying spline interpolation.

Mean annual rainfall

The location of the study area is an important factor for the distribution of rainfall. In the study area, three seasons have significant amount of rainfall out of the four seasons. The well marked hills in the north and south directions play a key role in the spatial distribution of rainfall.

Figure 2.7 seasonal rainfall distribution

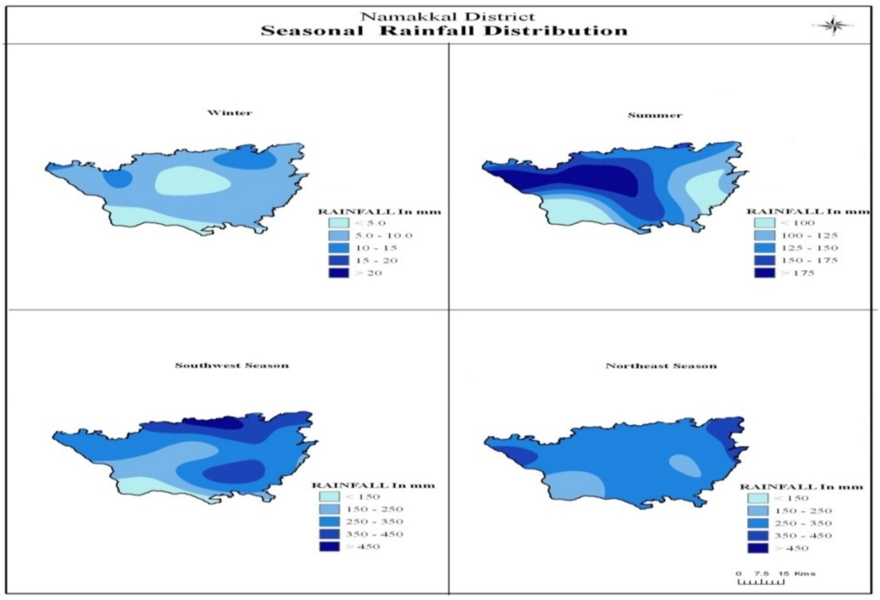

Figure 4: Seasonal rainfall distributions

2.4 Trend Analysis

1) Annual: Trend analysis of the study locations was carried out to understand the long-term changes in rainfall and their magnitude of change. The change in amount of yearly rainfall will directly affect the availability of water. Therefore, it is vital to know whether there is a decrease in rainfall quantity so that, the information can be used for regulating the planning and management of irrigation project and water resources associated issues. Annual trend analysis revealed decrease in 6 out of 7 locations witness a decrease in rainfall. The only locations Paramathy had increasing trend while all other locations had negative trend. Among the locations that witnessed a decreasing trend of rainfall, Rasipuram had the highest decrease (11.38 mm) followed by Namakkal (10.65 mm).

2) Non monsoon season: Further the data was segregated seasonally to analyze the trend in the seasonal rainfall. Interestingly, all other seasons had varying trends among the study locations. All the locations had a decreasing trend in winter rainfall ranging from 0.71 mm over Mangalapuram to 0.25 mm over Paramathy and Sendamangalam. During summer, out of 7 rainfall locations 3 had increasing trend during the study period. Among the locations witnessed the increasing trend is maximum over Kumarapalayam (2.03 mm) location and the minimum is found over Mangalapuram (0.66 mm) location. The ranging of decreasing trend is varied from 0.86 mm to 0.43 mm during the study period. Tiruchengode has the highest decrease of rainfall and Rasipuram had the lowest among the rainfall locations in the study area.

3) Monsoon seasons: Namakkal district gets maximum rainfall during the monsoon seasons. As per the rainfall data analysed over the study area the district receives maximum rainfall during SWM season. Even though, the district receives maximum rainfall during SWM the only locations Paramathy had positive trend while all other locations had negative trend. Among the negative trend location Rasipuram had a highest decrease of 8.88 mm and the lowest decrease is identified in Mangalapuram (2.16 mm) followed by Kumarapalaym (3.33 mm) during the study period over the study area. During NEM season among the rainfall locations the increasing trend is witnessed only in two stations they are Paramathy (2 mm) and Sendhamangalam (0.31 mm). All other location in the district had a decreasing trend during the study period. Among the decreasing trend the highest decrease is observed over Namakkal (2.34 mm) and the lowest is noticed over Managalapuram (0.39 mm) station. It is observed that comparatively less amount of rainfall is received in NEM season than SWM season in the area however two stations Paramathy and Managalapuram shows increasing trend during the study period over the study area.

Figure 2.8 Rain gaugestation

2.5 GROUND WATER REPORT OF NAMAKKAL DISTRICT

In Tamil Nadu, the surface water resources are fully utilized by various stake holders. The demand of water is increasing day by day. So, groundwater resources play a vital role for additional demand by farmers and Industries and domestic usage leads to rapid development of groundwater. About 63% of available groundwater resources are now being used. However, the development is not uniform all over the State, and in certain districts of Tamil Nadu, intensive groundwater development had led to declining water levels, increasing trend of Over Exploited and Critical Firkas, saline water intrusion, etc.

ADMINISTRATIVE SET UP

The Geographical area of the District is 342930 Heataresaccountingfor 2.64% of the geographical area of the Tamilnadu. The Namakkal District comprises of 4 Taluks, 30 Firkas,15Panchayat Unions, 346 village Panchayaths with 391 Revenue villages. KolliHillsandMohanur blocks fall in two taluks partly. Namakkal District is Totally bifurcated into 30 Firkas.

Hydrogelogy

(i) Major Geological formations: Geology TheNamakkal district is mostly underlain by the Archaean crystalline, metamorphic complex. The Geology of the district is complicated due to recurring tectonic and magmatic activities occurred during the pre Cambrian period. The famous Sithampoondi complex known for its complex geology is situated in this district. There are four major groups of rocks in this district. They are

1. The older granulite group
2. The meta sedimentary group
3. The ultramafic and basic intrusives and
4. The younger pegmatoid granites.

a) Gneisses:

Gneisses are perhaps the oldest rocks in the district occurring widely in plains covering the four taluks. The general direction of foliation varies from EW to ENE-WSW with a high magnitude dip towards north or southeast. The gneisses are highly weathered upto 30m at some places, several ultramafic and basic rocks parallel to the foliation of the gneisses.

b) Charnockites:

The charnockites, coarse grained and bluish darkto grey in colour, have the second largest coverage in the district. They are exposed in the Kolli hills and Bodamalai hills. Some of them are garnetiferous and are massive and less weathered than the gneisses. They exhibit 2 to 3 distinct set of joints most of which arevertical, with steep dips. These rocks occur in the Godumalai, Chitteri, Nainamalai and Valaiyapatti areas of the district. Iron ore deposits are associated with quartz felspathic gneiss, garnetiferous quartz gneisses in Nainamalai area. These rocks are highly folded and jointed and less weathered.

c) Calc-quatrzites and crystalline lime stones:

These rocks are exposed in patches in Thiruchengode and namakkaltaluks. The thickness of the bands varies from a few metres to 10 m and the length extends to few kilometres. Their trend is in the NW-SE to NNW to SSE direction.

d) Anorthosites and Pyroxenites:

Massive and poorly jointed anorthosites bearing rocks are found near Sittampoondi complex. With a wide range of rocks associated with them are Chromite, pyroxenite, Anthophyllite, diopside, etc.,

e) Dolerite dykes and other intrusives:

There are a number of basic intrusive dykes in Namakkaltaluk. They are massive running in NE-SW to NNE SSW direction, in general parallel to the foliation direction of the gneisses. They are few metres in thickness and a few kilometres in length. Their contact with country rock is sheared at many places.

f) Granites and Syenites:

These types of rocks are found in Thiruchengodetaluk. They are massive and jointed poorly.

g) Laterites:

The physical weathering and leaching in the flat topped hillocks of Kolli hills have given rise to laterites rich in alumina. There are also few pockets of bauxite in these hills. The weathering ranges from 10 to 15m.

h) Alluvium and Talus

Thin Veneer of alluvium is found along the course of the Cauvery and Thirumanimuthar. However, alluvium of few metres thickness is found near the junction of the Thirumanimuthar with the river cauvery. The thickness of alluvium is 10-15 m in

Paramathi – Velur area. Talus consisting of cobbles and boulders is found at the foot hills of Kolli hills. Alluvium of 10 – 25 m thickness, which is important for groundwater development is found in the Nadukombai areas of Kolli hills. Several faults and shears occurring mostly with NE-SW trend, are expected to influence the course of groundwater movement, its storage and developmental potentials in the district.

Drilling of bore holes:

The occurrence and movement of groundwater in hard rock formations are restricted to the porous zones of weathered formations and the open systems of fractures, fissures and joints. The State Ground and Surface Water Resources Data Centre, during the course of investigation has drilled 55 boreholes spread over the entire district to find out the nature and behaviour of the subsurface material and their water holding and water yielding capability. There is considerable diversity in the nature of formalities even within the short distance. In general the drilled bore holes indicate that the weathered zone varies from 2 to 15 m below ground level, and jointed and fractured zone varies from 15 to 55 m below ground level.

2.7 Aquifer parameters

Hard rock formations:

The thickness of aquifer in this district varies between ground level and 45 m below ground level. The inter-granular porosity is essentially dependent upon the intensity and degree of weathering and fracture development in the bed rock. Weathering is deep in gneissic formation and moderate in charnockite formation. The range of aquifer parameters in hard rock area is given below.

Table 2.4 The range of aquifer parameters in hard rock area

Parameters	Range
Well yield in LPM	23-553lpm
Transmissivity (T) m2/day	9-25 m2/day
Permeability (K) m/day	0.26-1.63 m/day

(iii) Drilling:

The drilling types are different according to the formation of the terrain. In general, DTH rigs are used in Hard rock formations for drilling a borewell at a depth ranges from 30m to 200m, according to the extension of joints, fractures, lineaments, etc in an area. In Sedimentary formations, rotary rigs with different rotors used according to the Tube well's diameter. The Bento novate clay is used in rotary rigs to avoid the collapse of the Tube well. The sedimentary tube wells are drilled up to a depth of 30m to 300m depending on the area, yield,etc. In alluvial formations, the hand rotary used for drilling tube wells ranges from 10m to 15m.In river beds, infiltration tube wells used for extraction of groundwater.In Hard rock, the well designing is simple. The upper top soil and highly weathered zone is cased with PVC pipe and the remaining weathered, Fissured, Jointed portion is left as it is. In Namakkal District, the weathered zone ranges from 1.0m to 12.0m. In Granitic gneiss area, the highly weathered portion will be more up to 15m but in charnockite area, the weathered zone will extend up to 8.0m to 10.m only. In Sedimentary area, the well construction depends on the occurrence of sand thickness in the referred area. The logger is also used in the construction to identify the area of good quality of water.

2.8 GROUNDWATER REGIME MONITORING:

2.8.1 Notes on existing water level scenario:

The water level is being monitored by State Ground & Surface Water Resources Data Centre from 1971 onwards from a network of 1746 observation wells (shallow open wells) located all over the State. The water level readings are observed in the first week of every month by the field officers. In Namakkal District, 206 observation wells and 56 piezometers,totally 262 wells are monitoring on Monthly basis. The Central Ground Water Board also monitors the water level from 900 numbers of wells spread all over the State. They observe water level four times in a year. (i.e January, May, August and November). The collected water level data are uploaded in GWDES software and database is maintained regularly for analysing the water level trend with rainfall. From the Monitoring network of wells, the selected representative wells are taken for Resource Estimation computations. In Namakkal District, during the pre monsoon, the water level generally in declining trend ranges from G.L. to 15m. The depth of well below GroundLevel 12.0m are become dry during hot season like May, June, July. In the post monsoon, the water level generally in upward trend due to rainfall and it may reach the Ground Level also. The water level trend maps for pre and post monsoons are included as Annexure- I & II.

2.8.2 Long term trend of water level:

The long term fluctuations of water levels range from G.L. to 14.0m in many parts of the Namakkal District. The analysis reveals that the water level has gone down in the north, west and central parts of the Namakkal District. The inference taken from the annual fluctuation is due to lack of rainfall which in turn affects the groundwater levels in phreatic aquifer. The seasonal fluctuation study reveals that due to necessity for development of ground water for different sectored needs and due to failure of monsoons, the water level has gone down. The hydrograph of observation wells water level trend from 2005 to 2017 enclosed as Annexure – III and water level trend from 2000 to 2017 of Piezometers enclosed as Annexure – IV for Namakkal District.

2.8.3 Existing network of Monitoring wells:

In Namakkal District, the existing network of monitoring wells is 262 wells, 206 wells are observation wells and 56 wells are piezometers. These wells are observed for every month water level.

Table 2.5 Namakkal District: Observation Wells - Location and Co-ordinates

Well No	District	Tahsil/Taluk	Block/Mandal	Village	**Latitude**	**Longitude**
53612A	Namakkal	Namakkal	Namakkal		11°45'74"	78°09'45"
53603	Namakkal	Sendamangalam	Kalappanaickenpatty	Belukurichi	11°23'08"	78°15'15"
53624	Namakkal	Puduchatram	Puduchatram	Elur	11°05'99"	78°04'35"
53607	Namakkal	Erumaipatti	Kasthuripatti	Kasthuripatti	11°08'28"	78°20'00"
53616(A)	Namakkal	Mohanoor	Palapatty	Palapatty	11°05'18"	78°04'35"
53854 AY	Namakkal	Rasipuram	Namagiripetai	Pudupatti	11°29'35	78°16'30"
53608A	Namakkal	Mangalapuram	Namagiripetai	Namagiripetai	11°48'27"	77°26'48"
53910	Namakkal	Tiruchrngode	Elachipalayam	Chinnamanali	11°22'34"	78°04'35"
53618	Namakkal	Kumarapalayam			11°26'47"	77°41'39"
53617	Namakkal	Paramathy	Paramathivellur	Palapatti	11°15'25"	78°02'52"

2.8.4 Data Constraints:

The following are constraints in collecting the water level data in the field and validating the data are:

1) The water level data are collected on the monthly basis in the referred observation wells and piezometers. The collected data is not sufficient quantity for analyzing purpose due to drying of wells, Wells abounded by various reasons, lack of selecting the alternate wells, lack of open wells available for monitoring purpose due to increased usage of bore wells in

the villages, Panchayats, etc. In many villages, the water supply schemes implemented by overhead tank supply or mini energised pumps and the existing open wells are not used generally by the villagers and moreover, they filled with garbage.

2) The number of bore wells should be increased for monitoring purpose.

3) The site selection of new bore wells should be based on the Geological methods.

4) Strengthening the network of monitoring wells by closing the gaps in the network.

5) Maintenance cost should be allotted to maintain the bore wells on the periodical basis to maintain the quality as well as yield.

6) Installation of Automatic water level recorders in the sensitive and more water level fluctuation in the bore wells will helpful to monitor the extensive depletion of groundwater areas.

7) Upgrading the measuring instruments will helpful to take accurate reading of water levels in the field.

8) Upgrading the soft ware will helpful to minimize the errors and increasing the accuracy of data.

9) Erecting the Telemetric water level recorders in the over exploited Firkas will helpful to monitor the over extraction of groundwater.

10)Lack of manpower and transporting vehicles are also major problems for data collection in the field in proper time.

2.9 DYNAMIC GROUND WATER RESOURCES:

The State Ground and Surface Water Resources Data Centre has estimated the ground water resources of Tamil Nadu periodically in co-ordination with the Central Ground Water Board, Government of India , Ministry of Water Resources, Chennai, based on the Methodology evolved by the Ground Water Resources Estimation Committee, 1997 (GEC 97). Groundwater potential assessment is a dynamic one and not static.While assessing an area, the following factors can be considered such as Geology,Total Irrigated Area, Total Number of Wells used for Irrigation, Water Level Data for the past five years, Average Rainfall, Total Recharge, Irrigation methods adopted in the area, Cropping pattern details, Seepage factor, Specific yield, Geological conditionsprevailing in that area, Recharge through Artificial recharge structures, etc. Groundwater potential assessment proposal should be presented for approval in the Central and State Level Working Group Committees and then, presented for final approval in the Central Level Committee as well as State Level Committees.

The Ground Water Potential Assessments as on January 1992 and January 1997 were done in the State, taking the Panchayat Union Block as an Assessment Unit and the entire State was categorized as Dark, Grey and White areas. The Blocks with more than 85% to 100% ground water development (extraction) were categorized as “Dark Blocks” and the blocks with ground water development between 65% to 85% were categorized as “Grey Blocks” and blocks with less than 65% ground water development were categorized as “White Blocks”. Subsequently, the Ground Water Potential Assessment was done as on March 2003 and as on March 2009. In these assessments, the Panchayat Union Blocks in Tamil Nadu were categorized as Over-Exploited, Critical, Semi-Critical, Safe and Saline instead of Dark, Grey and White blocks. The Blocks with more than 100% extraction were categorized as “Over Exploited Blocks”, the blocks with 90% to 100% extraction as “Critical Blocks”, the blocks with 65% to 90% extraction as “Semi Critical Blocks”, the blocks with less than 65% extraction as “Safe Blocks” and the bad quality blocks were categorized as “Saline Blocks”. No schemes should be formulated in over exploited and critical blocks - “Notified Blocks – A category – (Stage of Groundwater extraction is 90% and above)”.

The re-estimation of groundwater resources in the State as on March 2011 and as on March 2013 can be assessed in Micro Level basis. In these assessments, the assessing unit is Firka(Unit of Taluk) and categorized as Over-Exploited, Critical, Semi-Critical, Safe, and Saline Firkas. As on March 2013 assessment, in the Namakkal District

Based on the Estimation of Ground Water Resources of Tamil Nadu State as on March 2013, Out of 1139 Firkas in the State, 358 Firkas are categorized as “Over Exploited Firkas”, 105 Firkas are categorized as “Critical Firkas”, 212 Firkas are categorized as “Semi Critical Firkas”, 429 Firkas are categorized as “Safe Firkas” and 35 Firkas are categorized as “Saline Firkas”. When compared to last assessment as on March 2011, the “Over Exploited Firkas” comes down from 374 to 358 Firkas, the “Critical Firkas” increased from 48 to 105 Firkas, the “Semi Critical Firkas” comes down marginally from 235 to 212 Firkas, the “Safe Firkas” comes down marginally from 437 to 429 Firkas and the “Saline Firkas” remains same as 35 Firkas. The alteration of Firkas are due to the construction of Artificial Recharge structures such as Check Dams, Recharge Wells, Recharge shafts, percolation ponds; etc was constructed in the “Over Exploited Firkas” by various departments.

2.10 Methodology adopted for Estimation of Ground Water Potential :

The present methodology used for resources assessment is known as Ground Water Resource Estimation Methodology - 1997 (GEC'97) .In GEC'97, two approaches are recommended - water level fluctuation method and norms of rainfall infiltration method. The water level fluctuation method is based on the concept of storage change due to differences between various input and output components. Input refers to recharge from rainfall and other sources and subsurface inflow into the unit of assessment. Output refers to ground water draft, ground water evapotranspiration, base flow to streams and subsurface outflow from the unit. Since the data on subsurface inflow / outflow are not readily available, it is advantageous to adopt the unit for ground water assessment as basin / sub basin / watershed, as theinflow / outflow across these boundaries may be taken as negligible. In each assessment unit, hilly areas having slope more than 20% are deleted from the total area to get the area suitable for recharge. Further, areas where the quality of ground water is beyond the usable limits should be identified and handled separately. The remaining area after deleting the hilly area and separating the area with poor ground water quality is to be delineated into command and non-command areas. Ground water assessment in command and non-command areas are done separately for monsoon and non-monsoon seasons.

The rainfall recharge during monsoon season computed by Water Level Fluctuation (WLF) method is compared with recharge figures from Rainfall Infiltration Factor (RIF) method. In case the difference between the two sets of data are more than 20% then RIF figure is considered, otherwise monsoon recharge from WLF is adopted. While adopting the rainfall recharge figures, weight age is to be given to WLF method over adhoc norms method of RIF. Hence, wherever the difference between RIF & WLF is more than 20%, data have to be scrutinized and corrected accordingly. During non-Monsoon season, rainfall recharge is computed by using Rainfall infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-Monsoon recharge. In case of areas receiving less than 10% of the annual rainfall during non-monsoon season, the rainfall recharge is ignored.

The total annual ground water recharge of the area is the sum-total of monsoon and non-monsoon recharge. An allowance is kept for natural discharge in the non-monsoon season by deducting 5 to 10 % of total annual ground water recharge.The balance ground water available accounts for existing ground water withdrawal for various uses and potential for future development. This quantity is termed as Net Ground Water Availability.

Net Ground Water Availability = Annual Ground Water Recharge - Natural discharge during non-monsoon season.GEC'97 methodology has recommended norms for various parameters being used in ground water recharge estimation. These norms vary depending upon water bearing formations and agroclimatic conditions. While norms for specific yield and recharge from rainfall values are to be adopted within the guidelines of GEC'97, in case of other parameters like seepage from canals, return flow from irrigation, recharge from tanks & ponds, water conservation structures, results of specific case studies may replace the adhoc norms.

The Gross yearly ground water draft is to be calculated forIrrigation, Domestic and Industrial uses. The gross ground water draft would include the ground water extraction from all existing ground water structures during monsoon as well as during non-monsoon period. While the number of ground water structures should preferably be based on latest well census, the average unit draft from different types of structures should be based on specific studies or adhoc norms given in GEC'97 report.

The stage of Ground water Development is defined by

Stage of Ground water = Existing Gross Ground water Draft for all uses X 100

Development (%) Net annual Ground Water AvailabilityThe units of assessment are categorized for ground water development based on two criteria – a) stage of ground water development and b) long-term trend of pre and post monsoon water levels. Four categories are - Safe areas which have ground water potential for development; Semi-critical areas where cautious ground water development is recommended; Critical areas; Over -exploited areas where there should be intensive monitoring and evaluation and future ground water development be linked with water sconservation measures.

3.1 CONCLUSION

The study of thirty seven rainfall station with long term rainfall data shows the annual mean rain is 844.49 mm, south west and northeast monsoon season contributes 337.95 and 340.69mm respectively. Both the monsoon seasons give 40% of rainfall each to the annual rain. The spatial distribution pattern is different because of the hills with different elevation spread across the study area. Significantly the summer season contributes 18.73%. The winter season receives minimum rainfall among the other season. The variability indicates more 100 % of variability observed in the winter season and the other three season the variability was below 100%, which indicates the dependable rainfall is available during these period. By observing the precipitation ratio of the east and south eastern side, more abnormality is found than the western side. In the south west and northeast season the area having more abnormality is very less. The rainfall frequency indicates more than 900 mm rainfall has higher frequency followed by 133 for less than 600. The overall observation shows except winter season, all seasons have rainfall without much variability.

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