

# A Spatio - Temporal Analysis of Selected Rainfall Characteristics: A Case Study of Vannathangarai Watershed, Tamil Nadu

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**Abstract:** Rainfall constitutes an essential component of the water cycle and is the prime source of groundwater recharge. In recent decades, groundwater exploitation has significantly increased, particularly for agricultural purposes, because large parts of the country have little access to rainfall due to frequent monsoon failures. In this context, an attempt is made to study the rainfall variability trend analysis. The study area selected for the research is the Vannathangarai watershed of the River Noyyal basin, the tributary of River Cauvery in South India. Rainfall data for 33 years were collected from 12 rain gauge stations in and around the watershed. The study explores the trends of rainfall, its variability, and the connection between rainfall intensity and the number of rain days. It is evident from the current analysis that October is the rainiest month, and the North-Western monsoon provides maximum rainfall. South West monsoon rains are highly variable than all other seasons. The western region receives the maximum rainfall than all other areas.

**Index Terms:** Co-efficient of Variation, Rainfall variability, Mean Monthly Rainfall, Monthly Rainfall Intensity, Rain days.

## I. INTRODUCTION

Precipitation is a major factor controlling the hydrology of a region. It is the main input of water to earth's surface and a knowledge of rainfall patterns in space and time is essential for an understanding of soil moisture, groundwater recharge, and river flows (Ward & M Robinson, 2000). The major share of Water, which is an indispensable resource, reaches earth surface through precipitation. Its quantity and quality varies from place to place and has been a matter of study worldwide. Rapid increase in population, urbanization, agricultural expansion, and

industrialization has lead to a higher level of human demand for water resources. As water demand increases, issues on water availability and demand become critical. This makes the management of water resources include assessing, managing and planning a complex task.

India, being largely an agrarian economy is still highly dependent on Monsoon rain, for its survival. The agricultural calendar in the country is aligned perfectly with the arrival of monsoon. A perfect monsoon presents a great yield, but a deficit or surplus has created havoc in the economy. The disastrous effect of monsoon failure is echoed in different sectors owing to the interdependence of the sectors. Also, there is a huge disparity in the amount of rainfall received at different locations and at different times. An enormous amount of rainfall in a shorter duration can lead to flooding, especially in urban areas. In some places, the total amount of rainfall received during a year might have occurred in a few days; this is dangerous as more rain in less time may always lead to higher runoff and lesser recharge. This will result in the removal of topsoil and will create water scarcity in the dry period as the water table may not be having sufficient water owing to lesser percolation. Many studies have been conducted in this regard to analyze the trend and pattern of rainfall and it's relation with the number of rainy days.

An attempt was made by Olsacoaga to study the relation between rainfall and rain days for 5 years of 10 stations in Argentina (Olascoaga, 1950; Nandargi & Mulye, 2012). His observation was that a normalized rainfall curve was the fitting tool to analyze such a relationship. Ananthakrishnan & Soman studied the normalized rainfall curve in detail using the daily,

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monthly, seasonal and annual rainfall data for over three decades of 15 stations across India and suggested that the daily rainfall distribution can be delineated using a normalized rainfall curve (Nandargi & Mulye, 2012; Ananthakrishnan and Soman 1989). Rajendran and Venkatasubramani (2017) used Frequency analysis to predict how often the values of a variable, say rainfall, may occur. It was considered as an effective tool in determining and designing rainfall and discharge capacity along drainage structures concerning its hydraulic capacity.

This present study is intended to analyze the rainfall characteristics, which includes:

- a. The mean monthly, seasonal and annual rainfall
- b. The monthly, seasonal and annual rainfall variability
- c. The number of rain days and rainfall intensity.

## II. STUDY AREA

For any study related to the management of water resources, a watershed-based study has far-reaching effects, as watershed follows the natural pattern of terrain development. The area chosen for the current study is the Vannathangarai watershed of River Noyyal basin. The Noyyal is a tributary of the river Cauveri and originates in the Velliangiri Hills, which is a part of the Western Ghats. This watershed forms at the headwaters of River Noyyal and includes part of Coimbatore and Tiruppur districts of Tamil Nadu. The river travels through the cities of Coimbatore and Tiruppur and meets the Cauveri in Karur district. The “Noyyal” is a sacred river in Tamil history.

Coimbatore district occupies a major share of the region, while only marginal areas of Tiruppur district is confined to this watershed. It is bounded by Palakkad district of Kerala to the west, Nilgiris district to the North, Tiruppur to the north and east and parts of Coimbatore district to the south. This watershed is of paramount importance as the headwaters of the river Noyyal lies inside this. The western portion of the watershed embraces a small portion of the leeward side of the Western Ghats above the Palakkad Gap.

The area of the Vanathangarai watershed accounts for 1512 square kilometres. This watershed is the most thickly and densely populated area of the whole Noyyal river basin. A major metropolitan centre in Tamil Nadu, Coimbatore, which is the second-largest urban agglomeration in the state after the capital city lies inside the watershed. Also, many parts of Tiruppur district, which is a major cotton-growing hub as well as possesses lots of cotton dyeing units and cotton textile mills, is included in this study area.

The area is characterized by the presence of shallow weathered / buried pediplain, ridge type structural hills, shallow

and moderately buried pediment, shallow flood plain, etc. Almost the whole eastern half of the area is filled by shallow weathered / buried pediplain. Quartz vein, granitoid gneiss, conglomerate sandstone, granite, ultrabasic rocks, carbonatites are some of the major geological features seen in the region. There are different varieties of soil seen in the study area. Red clayey, red gravel loam, calcareous gravel loam, gravel clay are the major soil types seen in the region

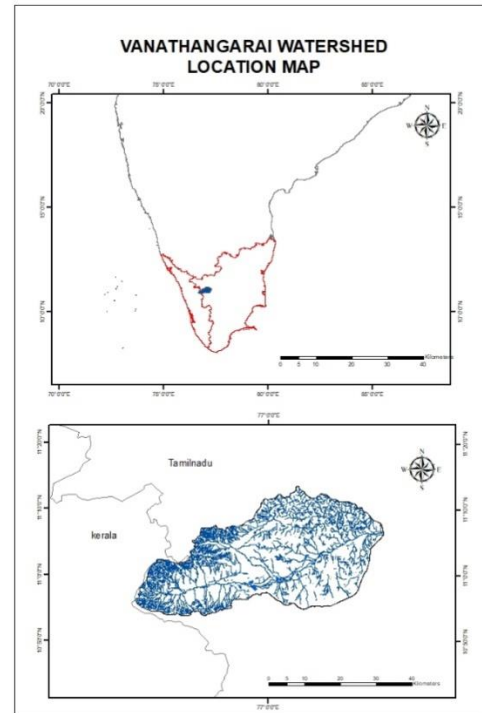


Fig.1: Location Map

## III. MATERIALS AND METHODS

The present study is done with the rainfall data collected from the Tamil Nadu Water and Drainage (TWAD) board. Daily rainfall measured in millimetres for 33 year period from 1985-2017 was collected for Coimbatore and Tiruppur districts. 12 rain gauge stations were identified in and around the study area. From the daily rainfall data, mean monthly, seasonal and annual rainfall, monthly, seasonal and annual rainfall variability and number of rain days were calculated. These were mapped using Arc GIS 10.3.

Variability is defined as the deviation from mean or ratio of the standard deviation to the mean rainfall and in other words variability of coefficient of variation (Sreevidhya & Gobu, 2017). The coefficient of variability of rainfall is the standard deviation from the mean expressed as percent of the mean annual rainfall (Sukumar et.al., 2016). Variability is given by the formula

$$CV = [SD / \text{Mean}] * 100$$

Based on these, the study was carried out and the results are portrayed spatially on the maps.

#### IV. RESULT AND DISCUSSION

The study is based on rainfall data received from 12 rain gauge stations situated in and around the study area. The selected rain gauge stations are Agricultural College, Annur, Chithiraichavidi Anaicut, Coimbatore Airport, Gomangalam, Tirupur, Suler, Periyanaickanpalayam, Mettupalayam, Sulthanpet, Thondamuthur and Podanur Railway station. The daily rainfall data was used to compute the monthly, seasonal and annual rainfall totals. The number of rain days was also calculated from the collected rainfall, data.

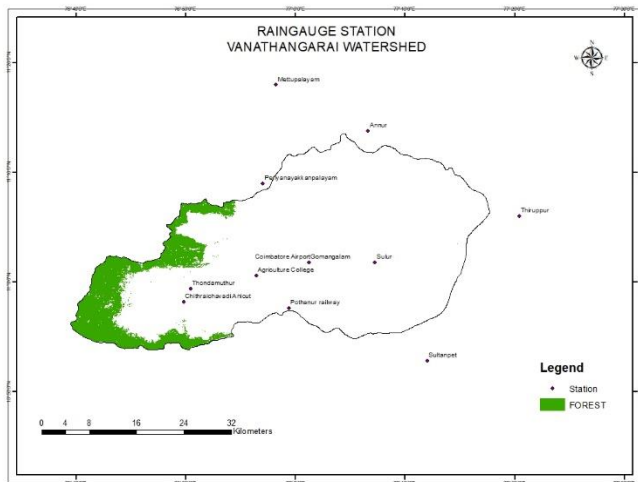


Fig. 2: Rain Gauge Stations

##### A. Mean Monthly Rainfall

It is the average rainfall received during the 33 years from 1985 to 2017 during each month. In most of the places, January has the lowest rainfall while October has recorded the highest rainfall. The amount of rainfall tends to increase gradually from January to October and tends to decrease after that. The percentage amount of rainfall received during each month is as given January(1.10), February(1.81), March(3.57), April(8.10), May(9.43), June(5.32), July(5.55), August(5.91), September(9.44), October(24.22), November(20.36) and December(5.18). A notable feature is that during the rainy months, the amount of rainfall is more along the western margin of the area, which is the part of Western Ghats.

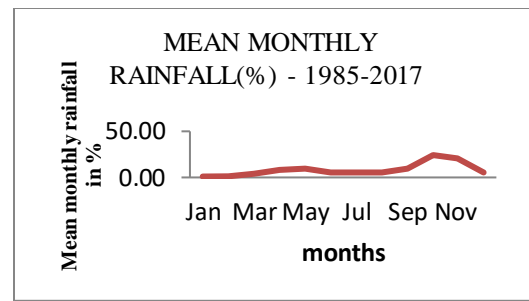


Fig. 3: Distribution of Mean Monthly Rainfall (1985-2017)

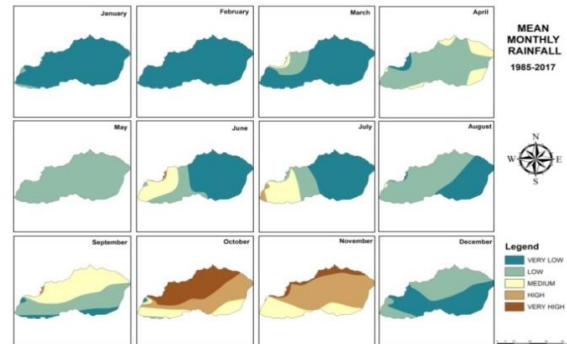


Figure 4: Map of Mean Monthly Rainfall-1985-2017

##### B. Mean Seasonal Rainfall

This is the average rainfall received during each season for 33 years. For the study, Indian seasons are classified as winter or Cold Weather season which is from early December to February, Summer or Hot weather season from March to May, South West Monsoon season running from June to September and North-East Monsoon or retreating monsoon season during October and November. The prominent rainy season in the study area is the Northeast monsoon season followed by southwest monsoon and summer monsoon. Winter season is characterized by very scanty rainfall.

Table 1: Mean Seasonal Rainfall- 1985-2017

Station	Winter	Summer	S.W Monsoon	N.E Monsoon
Agri. College	48.41	136.77	171.47	283.96
Annur	26.09	91.70	137.17	157.38
C.C Anicut	52.89	123.59	235.07	256.44
Cbe. Airport	45.23	119.48	136.93	278.90
Gomangalam	42.63	115.04	124.10	258.24
P .N.Palayam	68.82	139.98	174.49	337.88
Sultanpet	39.67	137.99	123.41	231.84
Mettupalayam	98.36	169.92	178.47	344.56
Suler	39.36	126.50	98.23	261.76
Thiruppur	40.08	118.42	148.73	271.54
Thondamuthur	41.36	126.00	244.05	289.59
Pothanur RS	42.19	122.23	126.19	254.38

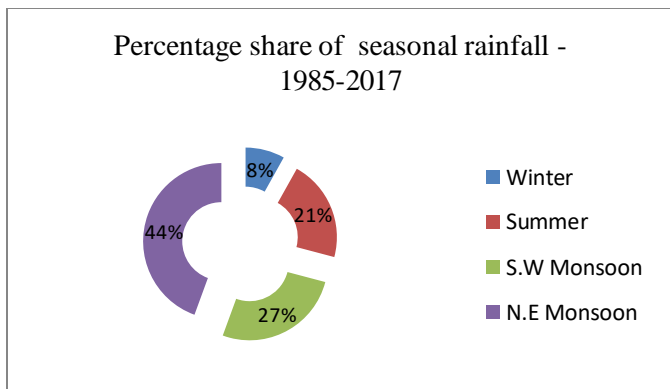


Fig. 5: seasonal distribution of rainfall for all the stations during 1985-2017

The percentage share of mean seasonal rainfall during each season is as follows: Winter (8.08), Summer (21.11), Southwest monsoon (26.23), and northeast monsoon(44.58). during the northeast monsoon season, most of the areas are receiving high to very high rainfall. This is the principal rainy season for Tamil Nadu. In other parts of the state, southwest monsoon does not yield good rainfall, but this area, since it is lying almost parallel to the Palakkad Gap region experiences the influence of the southwest rain in Kerala and receives a fairly good amount of rain during that season.

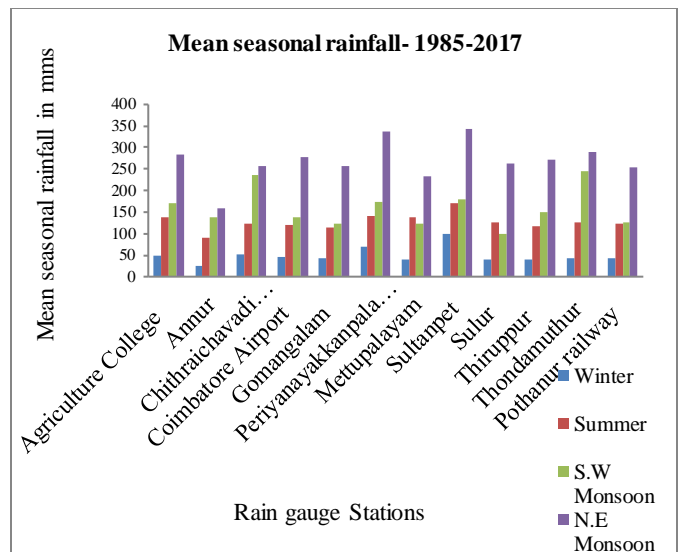


Fig. 7: Station wise distribution of Mean Seasonal Rainfall- 1985-2017

C Mean Annual Rainfall

This is the average rainfall received in each station during the last 33 years (1985-2017). The highest amount of rainfall is received in Mettupalayam, followed by Periyanaickenpalayam, both are located along the wetter western margin. The lowest mean annual rainfall is recorded at Annur, along the eastern margin. It is visible from the spatial distribution of rainfall that the western part of the study area receives higher rainfall and it decreases progressively towards the east.

Table 2: Mean Annual Rainfall 1985-2017

Station	Mean Annual Rainfall
Agriculture College	53.38
Annur	34.36
Chithraichavadi Anicut	55.67
Coimbatore Airport	48.38
Gomangalam	45.00
Periyanaickampalayam	60.10
Sultanpet	44.41
Mettupalayam	65.94
Sulur	43.82
Thiruppur	48.23
Thondamuthur	58.42
Pothanur RS	45.42

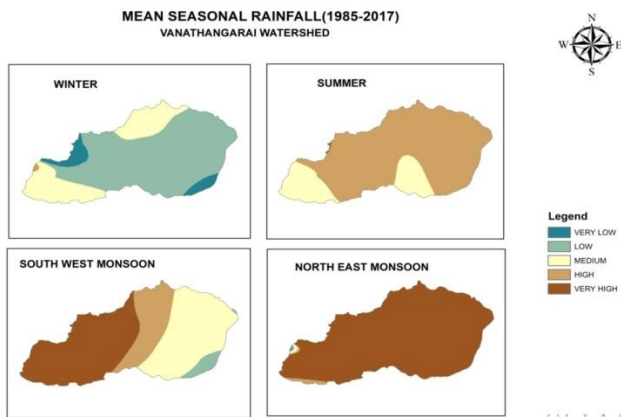


Fig. 6: Mean Seasonal Rainfall Map- 1985-2017

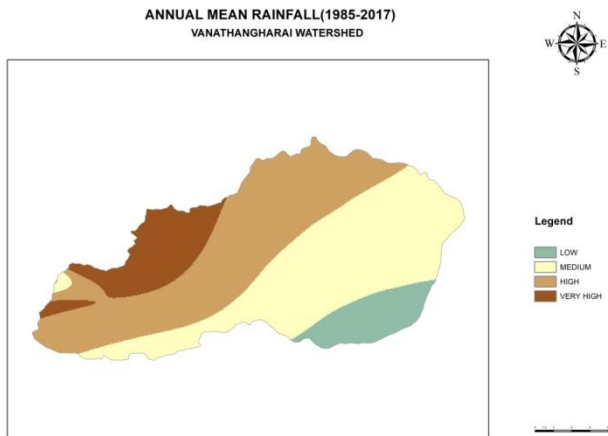


Fig. 8: Mean Annual Rainfall distribution- 1985-2017

*D. Monthly Rainfall Variability*

Variability is defined as the deviation from the mean or ratio of the standard deviation to the mean. It is expressed in percentage.

The variability distribution clearly shows that the initial months are highly variable in terms of rainfall. Rainfall during February is considered highly variable. The variability during the summer months is moderate. October followed by November is the highly reliable month in terms of rainfall.

The highest variability expresses the lowest reliability and vice versa. Coming to the aspect of spatial variability, area near the western margin has shown the lowest variability which is increasing towards the east.

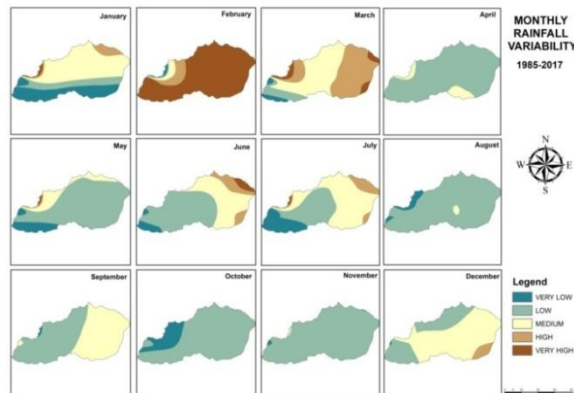


Fig. 9: Monthly Rainfall Variability distribution- 1985-2017

*E. Seasonal Rainfall Variability*

Among the four seasons, the northeast monsoon season has shown the least variability followed by summer and winter months. Highest variability is observed during the southwest monsoon months. This is because; southwest monsoon is not the primary source of rain in this region. Certain areas, along the

western side of the study area, which is covered by the hilly tracts receive rain during this period, while the areas farther away do not experience its effect.

Table 3: Seasonal Rainfall Variability 1985-2017

Station	Winter	Summer	S.W Monsoon	N.E Monsoon
Agriculture College	36.60	34.56	189.35	25.50
Annur	68.74	52.02	235.87	46.38
Chithraichavadi Anicut	31.86	37.70	126.36	26.42
Coimbatore Airport	37.84	39.47	219.25	24.62
Gomangalam	40.58	41.47	243.66	27.04
Periyamayakkan palayam	25.77	34.41	180.32	20.00
Sultanpet	46.90	36.88	272.29	33.13
Mettupalayam	17.64	27.62	168.18	18.96
Sulur	48.30	41.52	346.90	30.12
Thiruppur	49.11	45.78	230.12	30.20
Thondamuthur	49.06	44.09	139.60	29.55
Pothanur RS	42.90	41.33	258.54	28.12

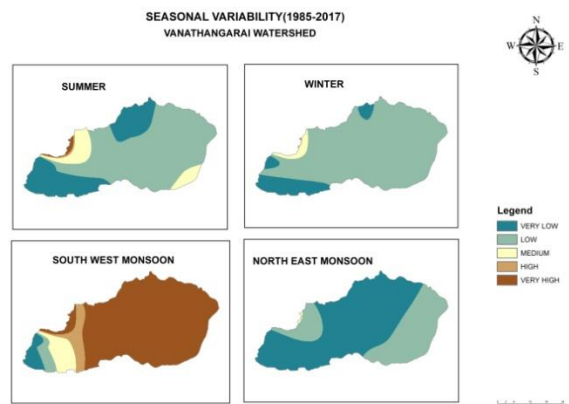


Fig. 10: Seasonal Rainfall Variability distribution- 1985-2017

*F. Annual Rainfall Variability*

Amongst the rain gauge stations, Mettupalayam has shown the lowest variability (236.71). The highest variability is observed in Annur, where the amount of rainfall recorded is the least. The southern part of the study area is characterized by very high variability, the central and eastern portion by medium variability, and the western and northern portions by very low variability.

Table 4: Annual Rainfall Variability- 1985-2017

Station	Annual Rainfall Variability
Agriculture College	371.38
Annur	574.36
Chithraichavadi Anicut	314.87
Coimbatore Airport	362.41
Gomangalam	389.81
Periyanayakkanpalayam	254.07
Sultanpet	311.41
Mettupalayam	236.71
Sulur	315.83
Thiruppur	286.96
Thondamuthur	237.17
Pothanur RS	336.59

Table 5.A: Total Number of Rain days 1985-2017 (contin..)

RG Stations	Jan	Feb	Mar	Apr	May	Jun
Agri College	23	21	41	141	183	213
Annur	14	17	41	126	161	107
CC Anicut	20	23	40	97	117	263
Cbe Airport	21	27	54	135	179	245
Gomangalam	4	4	24	63	70	86
PN Palayam	6	17	18	51	70	30
Mettupalayam	29	35	54	152	155	114
Sultanpet	8	10	28	87	105	107
Sulur	7	11	13	90	44	62
Thiruppur	15	13	31	104	126	67
Thondamuthur	5	10	21	46	52	105
Podannur RS	7	14	38	89	118	138

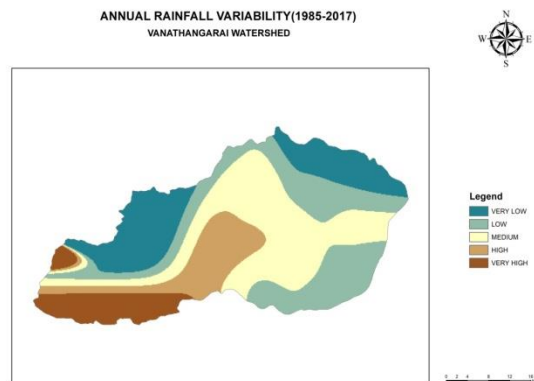


Fig. 11: Annual Rainfall Variability Distribution 1985-2017

G. Rain Days

The amount of rainfall received over any place is a significant factor in analyzing the amount of water available to meet the demands of various sectors like agriculture, industry, Hydroelectric power generation etc (Nandargi & Mulye , 2012). Jackson has pointed out that rainfall studies of a wider range of shorter periods are very significant. He suggested that there is a better relationship between monthly rainfall and the number of rain days than between monthly rainfall and mean daily rainfall intensity (Sukumar et.al., 2016 ; Jackson et.al., 1977). Here an attempt is taken to analyze the number of rain days in each month.

An analysis of the number of rain days of each 12 stations over the last 33 years from 1985-2017 shows that the maximum number of rain days occurred during October followed by November and July. January has the lowest number of rain days. Among the rain gauge stations, Coimbatore airport has recorded the maximum number of rain days (2214 days) followed by agriculture College (2052). Periyanackenpalayam has the lowest number of rain days.. This may be attributed to the local relief of that region. This particular station is surrounded by hills, which forms part of the Western Ghats , on all three sides, which may have induced heavy rainfall in a shorter period. Also, the terrain of that particular region is gently sloping, which will accelerate the rate of run off.

Table 5.B: Total Number of Rain days 1985-2017

RG Stations	Jul	Aug	Sep	Oct	Nov	Dec
Agri College	259	226	209	311	291	134
Annur	125	183	194	313	246	74
CC Anicut	279	209	157	314	240	92
Cbe Airport	257	232	226	368	323	147
Gomangalam	119	71	48	177	180	56
PN Palayam	33	64	85	135	131	60
Mettupalayam	150	171	179	333	295	126
Sultanpet	83	64	82	218	188	74
Sulur	16	75	44	252	116	76
Thiruppur	79	119	158	306	205	86
Thondamuthur	117	79	74	181	146	47
Podannur RS	128	111	88	249	207	84

The areas which have experienced the highest mean rainfall has recorded the lowest number of rain days. This will have a drastic influence on the surface of the region, as a higher rate of rainfall during a shorter duration will induce higher runoff and may aggravate soil erosion. This has also caused local level flooding at many places, that interrupt the daily normal life.

#### H. Monthly Rainfall Intensity

It is important to understand the intensity of rainfall, as it gives the relationship between the amount of rainfall received and its duration. Food & Agriculture Organization has defined the Rainfall intensity as the ratio of the total amount of rain (rainfall depth) falling during a given period to the duration of the period It is expressed in-depth units per unit time, usually as mm per hour (mm/h).

Here an attempt is made to study the monthly rainfall intensity, which is the ratio between total monthly rainfall and the total number of rain days. The rainfall intensity is an effective tool in analyzing the quantity of rainfall per time and it in turn helps in finding out the runoff.

Table 6.A: Monthly Rainfall Intensity- 1985-2017 (contin...)  
(expressed in mm / month)

RG Stations	Jan	Feb	Mar	Apr	May	Jun
Agri College	13.81	13.72	18.87	13.18	10.28	4.95
Annur	7.31	12.55	11.25	8.46	9.31	6.08
CC Anicut	16.78	21.36	21.30	15.01	15.14	8.09
Cbe Airport	9.07	10.93	14.19	10.48	9.84	2.92
Gomangalam	38.00	31.25	16.72	22.43	23.39	10.89
PN palayam	15.53	20.30	24.52	17.01	13.30	11.40
Mettupalayam	22.02	26.19	15.77	13.68	15.07	7.96
Sultanpet	14.39	13.37	22.59	21.04	19.91	9.87
Sulur	24.00	18.86	48.82	19.71	40.13	6.28
Thiruppur	7.33	12.33	13.54	13.75	16.33	9.86
Thondamuthur	19.40	22.13	34.55	18.90	22.64	14.96
Podannur RS	13.10	26.51	16.48	18.06	14.22	7.05

Table 6.B: Monthly Rainfall Intensity- 1985-2017  
(expressed in mm/month)

RG Stations	Jul	Aug	Sep	Oct	Nov	Dec
Agri College	4.86	5.57	9.98	15.88	15.24	7.40
Annur	5.43	6.97	9.91	9.72	8.75	7.37
CC Anicut	9.14	6.55	10.89	14.79	15.91	9.98
Cbe Airport	2.92	4.90	8.48	13.70	12.89	6.85
Gomangalam	9.04	10.15	20.63	21.29	22.10	17.89
PN palayam	9.62	12.94	15.34	21.89	18.70	11.05

Mettupalayam	4.82	9.70	12.53	18.22	15.64	11.85
Sultanpet	10.42	9.86	18.54	18.51	19.23	14.33
Sulur	24.66	9.72	39.29	17.61	36.20	12.15
Thiruppur	9.42	10.39	14.35	16.69	18.79	12.24
Thondamuthur	13.72	10.98	17.91	20.19	18.60	12.59
Podannur RS	7.58	7.95	13.78	17.23	18.60	10.56

The Rainfall intensity is not uniform throughout the study area. The lowest Rainfall intensity is observed during the June- July months. Southwest monsoon months have registered a low rainfall intensity. Highest Rainfall intensity is experienced during the North-eastern monsoon period. Generally, October and November have shown the highest rainfall intensity among the months.

Also another notable feature is that, during winter months, when the rainfall is generally low, the intensity is quite high, this may be because a fewer amount of rainfall recorded in a shorter duration. Among all the rain gauge stations, Sulur has registered the highest rainfall intensity during March. The lowest intensity is noticed at Coimbatore Airport during June July months. The station with the maximum number of rain days has also recorded the lowest rainfall intensity, thus pointing towards a fairly equal amount of rainfall over time. This is a very positive factor, as it leads to lesser runoff and higher percolation, inducing groundwater recharge.

#### CONCLUSION

Rainfall is the chief source of water for many sectors, and in a country like India, where there is over-dependence on monsoon rainfall for irrigation, the study about rainfall patterns, its variability, and intensity is of great significance. The present study has computed monthly, seasonal and annual, mean rainfall and its variability along with rainfall intensity. This region receives the lion share of rainfall during the North-eastern monsoon period. Monsoon rain during the South Western season is highly variable, which is not reliable. The watershed receives the maximum rainfall during north east monsoon season, and it is very reliable, where as south west monsoon is not that prominent, and is spatially varied. Only the regions lying in the west, adjacent to the Palakkad Gap region receives rainfall, while moving towards the east, the rain reduces considerably. October and November months are showing high consistency in terms of rainfall recorded. There is a huge disparity in the amount of rainfall received at different locations.

While the western areas of the region, lying close to the Western Ghats receives the highest rainfall, the places along the eastern region receives the lowest amount of rainfall. The month of October receives the maximum amount of rainfall, also has

the maximum number of rain days to its credit. The study provides insight into major rainfall characters for sectors like agriculture and its allied industries which are consistently dependent on rain for its water needs. This attempt facilitates the agriculturists to plan their activities according to the arrival and trend of rainfall. This also enables the farmers to identify the areas where the rainfall is deficit or surplus and plan accordingly. The farmers can decide the type of the crop, and the season to cultivate them based on the rainfall variability analysis. Water intense crops can be cultivated during north east rainy season. The other seasons can be devoted to the cultivation of crops that require limited water like millets. Studies like this pave the way for the administrators to implement rainwater harvesting techniques by identifying the spatial disparity in terms of water availability.

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