Rainfall Distribution and Variability in Coimbatore District, Tamil Nadu Using GIS Technique

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Abstract: Among the climatic elements the rainfall is the first index, ever thought of by farmers and climatic analyzers as it is the most important single factor which determines the cropping pattern of an area in general and the type of crop to be cultivated and its success or failure in particular. Therefore, the present study deals the rainfall characteristics of the Coimbatore District, which includes the spatial distribution and variability through different seasons, and frequency occurrences have been analysed through GIS environs. The study has used the long term 20 years (1995-2014) mean monthly rainfall data for 33 rain gauge stations, located in and around Coimbatore district. The mean annual rainfall variability of the study area is 28.3%. The area in and around Coimbatore district experiences high abnormality as the annual precipitation is 53.71% whereas the lowest is about 21.12% at Bhavai sagar. The entire study area is subjected to larger temporal fluctuations rather than the spatial distribution of rainfall. The south, southwest and northwestern parts of the district experience the heavy rainfall whereas the least rainfall areas are the east, northeast and southeastern parts of the district.

Keywords: *To Analysis the spatial variation of rainfall in Coimbatore district by using an geo spatial approach Arc map 9.3, Arc catalog 9.3 , GPS data , IMD collected data*

1. First-order headings

Introduction

All of the natural conditions, rainfall should be regarded as the fundamentals so far as progress of the society is concerned. Rather it has always been treated as a fundamental sector for the total development of the society S.K.Sadhukan (1987). Rainfall is a crucial agro-climatological factor in the seasonally arid parts of the world and its analysis an important perquisite for agricultural planning in India, Alak Gadgil (1986).

India is a tropical country its agricultural planning and utilization water is depends on monsoon rainfall, more than 75% of rainfall occurring during the monsoon season; monsoon rainfall is uneven both in time and space.

Study Area

Coimbatore serves as an entry and exit point to neighbouring Kerala and the ever popular hill station of Udhagamandalam (Ooty). It is the disembarking point for those who want to take the Mountain train that runs from Mettupalayam, just 35 kms from Coimbatore. There are also regular bus services from Coimbatore to Ooty. 11°07'30''E, 77°N, and 10°45'E, 76°30'N geographic coordinates.

Coimbatore, District is situated on the banks of river Noyyal between 11° 00' of north latitude and 77° 00' of East longitude. The total area of Coimbatore district is 254 square km. Coimbatore is located at an elevation of about 398 meters. The mean maximum and minimum temperatures during summer and winter varies between 35°C to 18°C. Highest temperature ever recorded is 41 °C and lowest is 12 °C.

Coimbatore is situated in the extreme west of Tamil Nadu, near the state of Kerala. It is surrounded by mountains on the west, with reserve forests and the (Nilgiri Biosphere Reserve) on the northern side. The eastern side of the district, including the city is predominantly dry.

Coimbatore is one among the industrially developed and commercially vibrant districts of Tamilnadu. It has got high concentration of small scale industries and medium and large scale industries. It is known as the Manchester of South India because of its well-developed textile industry and other industrial base. The third largest city of the state, Coimbatore, is one of the most industrialized cities in Tamil Nadu, known as the textile capital of South India or the Manchester of the South.
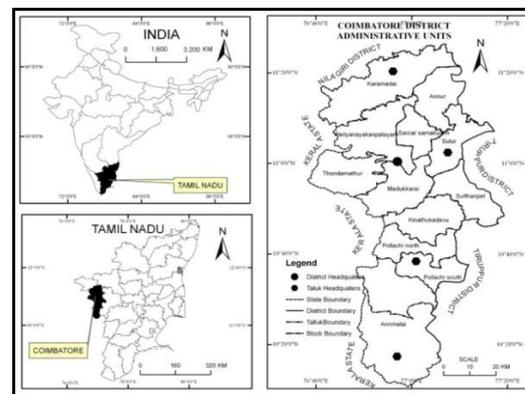

Fig1 Study Area Map

Methodology

- To collect the monthly rainfall data for a period of 20 years (1995-2014).
- To calculate the monthly, seasonally and annual rainfall pattern.
- To calculate the coefficient of variability around rain gauge stations.
- To prepare various spatial distribution maps using GIS software.

The present study includes interpolation of rainfall data in the form of point rain gauge readings from 33 rain gauge stations spread across the study area. The analysis has been carried out using Geographic information system (GIS).

The overall methodology adopted in the present study is shown in Figure. The point rainfall data collected from the statistical department of Coimbatore district has been analyzed and average annual rainfall has been computed. Base map showing the district boundary was digitized using toposheets. Layer showing the location of rain gauge stations was prepared in GIS platform.
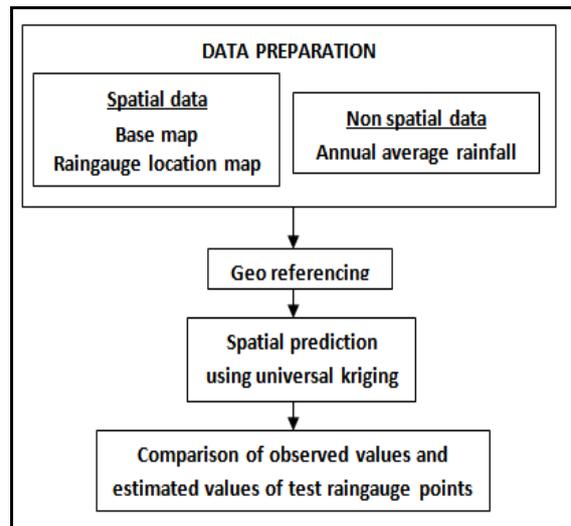
Flowchart indicating methodology

Table.1 *Long term (1994-2014) mean seasonal, annual precipitation and rainfall variability (in%)*

Station name	Winter	Summer	Swm	Nwm	Annual	Mean
Alaiyar nagar	26.1	175.4	302.4	398.3	902.2	225.5
Anaikatty	47.2	305.9	267.7	609.6	1230.5	307.6
Anaimalai	33.9	382.0	2983	503.6	3901.6	975.4
Annur	14.5	125.9	176.9	282.6	599.9	150.0
Attakatti	34.2	271.7	405.1	589.2	1300.2	325.1
Bhavani sagar	25.2	163.2	184.2	382.1	754.7	188.7
Chitrachavadi	18.2	87.7	260.1	398.1	764.1	191.0
Coimbatore City	12.1	101.2	189.2	329.8	632.3	158.1
Coonoor	160.1	332.6	374.5	894.3	1760.9	440.2
Kethi	36.2	421.8	752.5	801.2	2011.7	502.9
Kodanadu	53.5	285.4	423.3	754.1	1516.3	379.1
Kothagiri	48.3	265.7	384.4	692.1	1390.5	347.6
Krishnapuram	14.4	89.8	120.5	291.4	516.1	129.0
Mettupalayam	44.2	182.1	167.2	402.6	796.1	199.0
Nallar colony	33.2	135.2	187.1	402.1	757.6	189.4
Negamam	15.4	186.4	350.1	423.3	975.2	243.8
Ooty	12.5	231.6	602.1	389.2	1234.9	308.7
P.N.Palayam	26.4	154.3	227.1	532.7	940.5	235.1
Palladam	12.1	101.4	124.8	564.3	802.6	200.7
Pedamapatti	18.2	130.7	134.4	300.1	583.4	145.9
Peelamedu	18.2	110.9	124.7	422.9	676.7	169.2
Podanur	18.2	140.1	189.2	386.7	734.2	183.6
Pollachi	16.2	142.5	354.2	398.2	911.1	227.8
Poolakinar	21.5	133.3	102.3	339.2	596.3	149.1
Solaiyar nagar	32.4	334.7	2909.1	498.2	3774.4	943.6
Sultanpet	9.2	157.6	165.4	294.4	626.6	156.7
Sulur	10.2	159.2	135.9	452.7	758.0	189.5
Sundakapalayam	12.2	1243.0	173.1	1813.3	3241.6	810.4
Thirumurthinagar	28.3	122.5	1892.2	435.2	2478.3	619.5
Top slip	12.2	1702.3	444.5	398.2	2556.9	639.2
Upper niradam	30.1	334.7	3983.2	602.1	4950.1	1237.5
Valparai	36.2	348.9	2234.0	498.9	3118.3	779.5
Veetaikarnpudu	12.5	125.2	402.1	304.2	843.8	211.0

Source (IMD Chennai)

Mean Seasonal Rainfall

Winter

According to the rhythmical changes in the climatic element, the year is divided into four well-marked seasons. They are winter (Jan - Feb), summer (Mar - May), southwest monsoon (Jun - Sep) and northeast monsoon (Oct - Dec). The southwest and northeast monsoons are the two main seasons for agricultural activities.

However, the southeast monsoon accounts for largest share in the total annual rainfall within short spell. The winter rainfall in the months of January and February is only 1.9 %. During winter season the station receives the highest rainfall of 160.1 mm outside of Mettupalayam and decreases following the order of moderate, normal, low and very low rainfall regimes. The lowest rainfall of 9.2 mm is recorded at Sulthanpet, which is located in the opening area near Kridhnapuram.

The spatial pattern of winter rainfall is unique and totally different from other seasons. Fig no.2 Shows the spatial distribution of Rainfall during winter season.
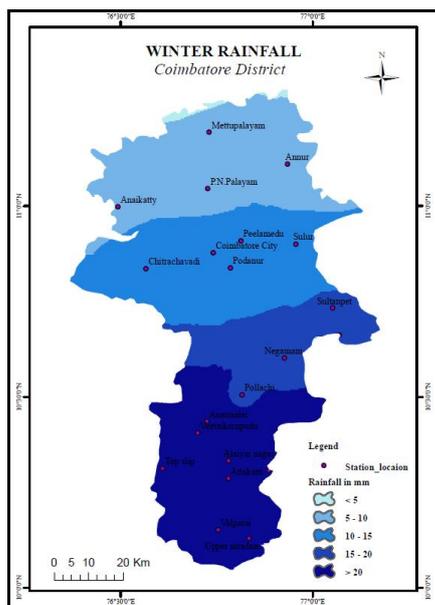

Fig2 Spatial distribution winter rainfall

Summer Rainfall

Summer receives more rainfall than the winter because the district is under rain-shadow region which is located in the leeward side of Western Ghats. Since the rainfall is confined to summer convection the variations in rainfall depend on purely local phenomena and the summer rainfall is associated with thunderstorm showers.

When compared with other parts of Tamil Nadu the summer rainfall is moderatly high in the study area. The summer rainfall contributes 18.9 % of annual

rainfall of the study area. A trough of high rainfall zone moves to the northeast in and around Sothuparai, which receives 348.4 mm of rainfall. From here, the rainfall decreases towards the central parts of the study area.

The trend follows the mean annual rainfall distribution. On contrast to winter, Chitiraichavadi receives the low summer rainfall of 18.9 mm. The lowest amount of summer rainfall is recorded in Krishnapuram and Sulur receiving 87.7 mm and 125.3 mm respectively. There is a much variation in the rainfall amount during summer and winter. Fig no.3 shows the spatial distribution of rainfall during summer season.
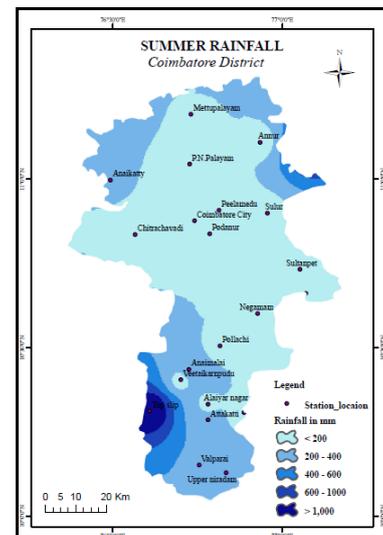

Fig3 Spatial distribution of rainfall during summer season

Southwest Monsoon

The study area receives 44.7 % of rainfall during this season. It is mainly associated with southwest monsoon rain bearing winds and elevation of topography.

During this season the rainfall of different stations within the study area the lowest of 102.3 mm at Poolakinar, 124.7 mm and 135 mm Sulur successively from north to south and they form very low and low trough. On either side of this trough, the rainfall increases succeeding following the normal, moderate and high rainfall zones, notably in the southern part whereas the northern rim of the district with normal rainfall category of 400 mm – 600 mm. while analyzing the stations in and around the study area the rainfall fluctuates from 120.5 mm at Kishapuram to the highest of 3983.2 mm at upper niradam.

Accordingly, the area under the lowest rainfall is also successively decreasing in the mid-portion of the study area. In this season the areal extent of very low and low category is as much as normal, moderate and high rainfall zones. Again it substantiates the earlier statement as the testimony for the area falls under

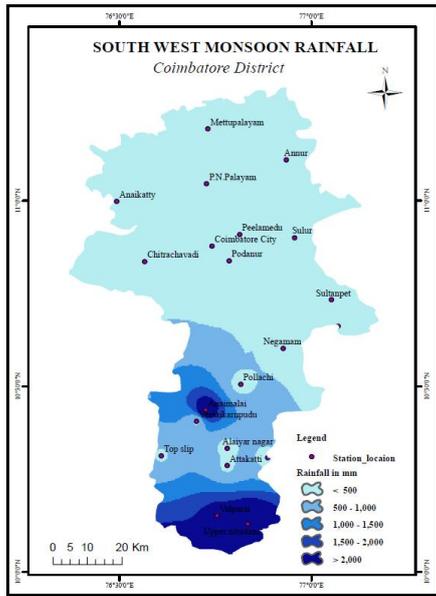semi-arid condition. Fig 4 illustrates the spatial distribution of rainfall in southwest monsoon.

Fig4 *Spatial distribution of rainfall in southwest monsoon*

Northeast Monsoon

The study area receives 34.5 % of the total annual rainfall during this season. The northeast monsoon followed almost the same trend of mean annual rainfall which exemplifies the dominance and intensity of northeast monsoon over the study area. The highest rainfall zone during this season concentrated over Sundakapalayam (1810 mm) and Anaikatti (608mm) in the vicinity of northern boundary of the study area, which receives more than 500 mm of rainfall. However, the adjacent station palladam receives the highest amount of rain for 564.3 mm.

From the northern rim, this is the hilly area towards south till Mettupalyam (402.6 mm), the rainfall descents as the elevation decreases drastically. Beyond this a larger portion of the study area up to Sulfur forms a bigger trough with very low rainfall zone of less than 282 mm Annur. From Annur, the rainfall increases towards east and extreme south of the study area comes under low and normal rainfall category. Fig 5 illustrates the spatial distribution of rainfall in northeast monsoon.
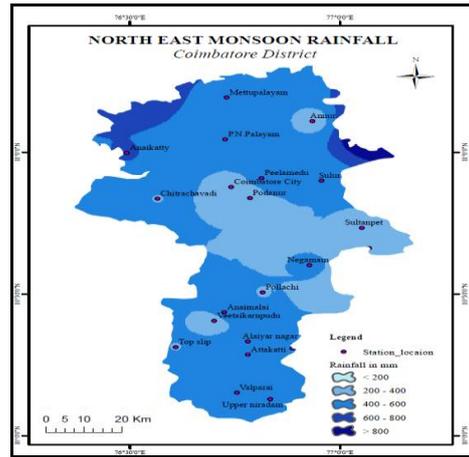

Fig5 *The spatial distribution of rainfall in northeast monsoon*

From foregoing analysis on the spatial pattern of rainfall during annual, winter, summer, southwest monsoon and northeast monsoon, it is noted that Krishnapuram is the breaking point station from where the rainfall increases or decreases on either side as the case may be.

In general, as the study area is bordered by hills except the north-east opening of the valley portion, it receives the highest rainfall in the northern and southern boundary of the study area. In contrast, the interior part receives relatively low – very low amount of rainfall as the area lies in the rain-shadow region of the valley floor. It is inferred that during all seasons except winter, the spatial distribution of rainfall pattern is controlled by elevation of the terrain.

Mean Annual Variability

According to Trewartha, the variability of rainfall may be defined as the deviation from the mean. The coefficient of variability has been worked out by using standard deviation method for the series of years. The variability gives the stability of rainfall in the district.

$$\text{Coefficient of Variability} = \text{SD/Mean} \times 100$$

Where, SD = Standard Deviation = $\sqrt{\Sigma d2/n}$

The coefficient of variability of rainfall is the standard deviation from the mean expressed aspercent of the mean annual rainfall. The isolines have been drawn on the basis of values compiled for 11 stations in order to bring out the spatial pattern (Table 2.2).

Table.2 *Long term (1995-2014) mean seasonal, annual precipitation ratio and rainfall variability (in %)*

Station Name	Rainfall Variability				
	WINTER	SUMMER	SWM	NEM	ANNUAL
Alaiyar nagar	125.38	77.40	49.21	43.58	25.00
Anaikatty	124.30	76.87	38.53	41.15	29.46
Anaimalai	134.50	65.03	75.50	48.76	29.08
Annur	140.35	55.87	37.12	41.99	26.20
Attakatti	143.50	67.11	46.92	29.63	29.86
Bhavani sagar	75.34	50.98	42.25	39.34	21.12

Chitrachavadi	143.34	58.70	66.53	52.03	33.06
Coimbatore City	186.30	67.18	61.79	81.89	49.90
Coonoor	234.23	57.95	54.71	459.00	38.92
Kethi	198.50	88.46	77.48	65.40	53.24
Kodanadu	110.23	67.29	77.61	51.77	30.66
Kothagiri	176.98	79.96	79.52	62.27	44.14
Krishnapuram	198.24	58.70	68.55	55.75	35.42
Mettupalayam	224.23	65.46	86.26	73.28	53.71
Nallar colony	221.30	69.45	52.60	58.87	35.12
Negamam	205.30	65.88	46.23	58.13	34.06
Ooty	243.40	82.35	71.06	47.46	32.94
P.N.Palayam	175.30	54.13	73.40	46.61	29.67
Palladam	234.40	78.17	77.25	58.03	43.63
Pedamapatti	222.43	80.44	45.65	59.51	33.24
Peelamedu	198.20	60.16	35.16	60.16	30.69
Podanur	190.10	65.63	70.99	55.58	33.68
Pollachi	192.20	73.83	93.53	49.36	36.45
Poolakinar	110.32	64.92	35.53	48.82	27.56
Solaiyar nagar	198.20	57.03	41.69	66.43	28.36
Sultanpet	186.20	65.34	31.56	55.74	22.59
Sulur	154.23	65.81	45.45	56.39	29.03
Sundakapalayam	154.20	82.03	72.23	52.50	33.76
Thirumurthinagar	221.10	66.11	63.59	60.94	43.95
Top slip	189.20	46.42	47.13	50.06	26.37
Upper niradam	132.10	51.17	42.85	43.91	34.33
Valparai	143.30	64.40	34.56	51.77	28.30
Veetaikarnpudu	135.40	74.96	44.87	61.92	41.12

Source (IMD Chennai)

Annual Variability

The annual variability varies from 23 to 42% in the study area (Figure 5.6). The lowest variability of 18% occurs at Coonor near Mettupalayam where the maximum rainfall is found in this district (389 mm). The areas lie in the openings of the valley namely, Bhavaishakar, Sulthanpet and Aliyar nagar a receives low variability of 21.3, 22.5 and 25.9% respectively which shows high dependability.

The stations located at the foot of the hills/vicinity of hills are under moderate-high variability. For example, Negamam, P.N.Palayam and Mettupalayam have the variability of 30.6 33.76, 34.06, and respectively whereas the stations located at the lower elevations adjacent to above experience normal variability in and around Coimbatore city (49.0%). From here, the variability steadily increases towards southwest and northeast till beyond Coimbatore city again which steadily decreases till the end of the mouth of the valley portion. Accordingly, the dependability also follows the same trend as stated above. Fig 6 illustrates the spatial distribution of rainfall in annual rainfall.

Winter Variability

Among all seasons (Figure no 7), the winter variability of rainfall is high which ranges between 75.3 – 243.8%. During this season, the variability is triple fold than summer, southwest and northeast monsoon.
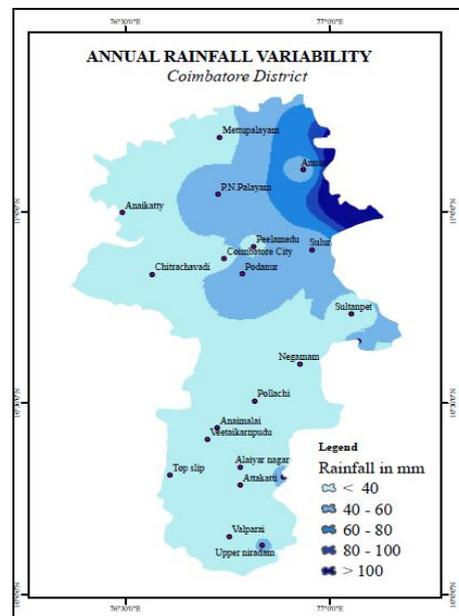

Fig 6 *spatial distribution of rainfall in annual rainfall variability*

Accordingly, the dependability of rainfall is also relatively very less. From the spatial distribution of winter variability, the eastern portion notably at the mouth of the valley and southeastern margin has very

low and low variability fall under less than 50 and 50-80% variability classes.

The southern portion covering Sulur, Upper niradam , valparai areas fall under normal variability (80-150%) which increases to moderate (175- 200%) and high (>225%) extend on either side towards north as well as southeast. As the variability ranges between 60 to more than 180% indicates that the rainfall is scanty (> 40%) and hence the dependability is unreliable.

However, cultivation practices like short-term crops are possible in and around Annur, Avinashi, Krishnapuram and Pollachi.
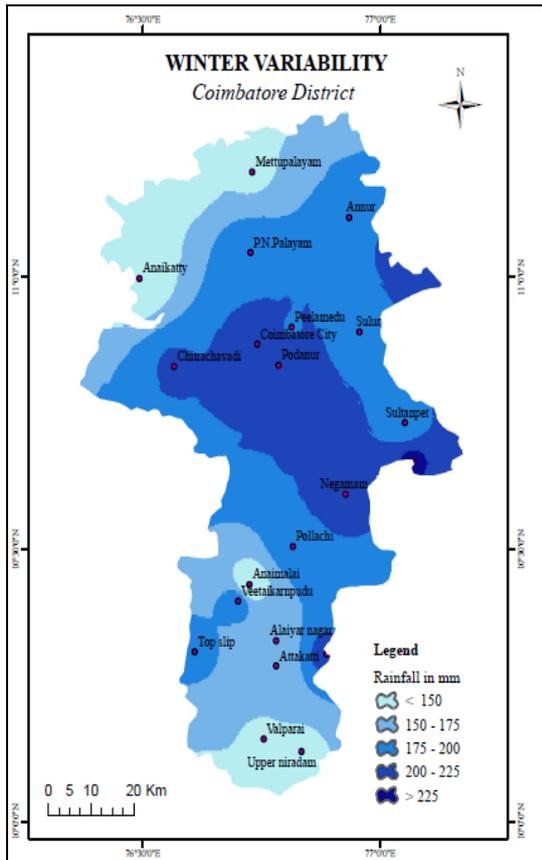

Fig 7 spatial distribution of rainfall in winter variability

Summer Variability

During the summer season, the pattern of rainfall variability is from NW to SE in the order of very low (< 50%), low (50- 60%), normal (60-65%), moderate (65-80%) and high (>80%) which increases succeeding. The very low and high variability occupy almost equal. The rest of low, normal and moderate are equally distributed orienting SW-NE which passes middle of the watershed. The variability during this season ranges between 60-655%. While comparing winter and summer the lowest variability class does not have much variation whereas the highest variability class is three fold less than winter which shows that there is a large variation in spatial distribution as well as trend.
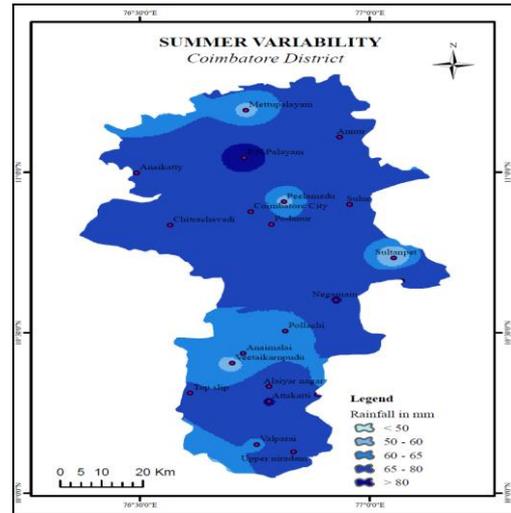

Fig 8 spatial distribution of rainfall in summer variability

Southwest Monsoon Variability

Among the 33 stations the variability is relatively low in Sulthanpet (31.6 %) which is located about 30 km away from southeastern rim of the Coimbatore city whereas the high is at Kethai (88.46%), located at the northern part of Nilgiri hills near Mettupalayam.

As far as the distribution of variability is concerned the district is divided into two halves, viz. northeastern and southwestern parts, which are separated by a line connecting Mettupalayam and southern margin of Coonor Nilgiri hills. In the southern portion, the low variability (< 50) starts from Valparai and Pollachi which increases towards southeast as much as above 50% that runs along the western margin till end of the northeast portion of the study area. Another stretch of low variability class starts from Erasakkanaickanur hills and increases towards west till margin of the Pothanur region. Fig no.8 illustrate the Southwest Monsoon Variability.
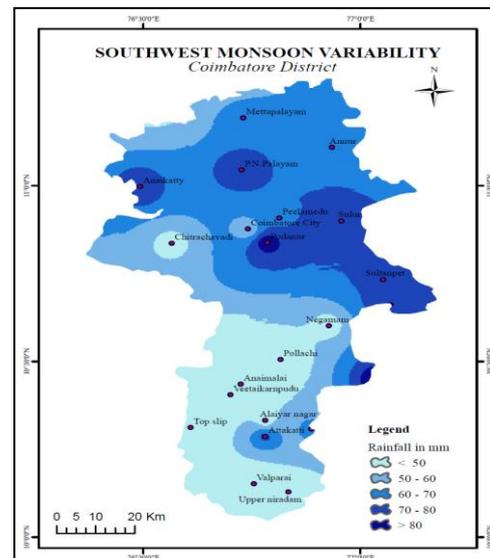

Fig 9 southwest monsoon variability

Northeast Monsoon Variability

The rainfall variability of northeast monsoon resembles almost the characteristics and the general pattern of mean annual rainfall variability. Owing to this nature, the annual rainfall variability reflects characteristics of NW monsoon season rainfall variability. This is the season gets more rain which is favorable for agricultural operation as the continuation of southwest monsoon rainfall.

A band of area under moderate variability class passes through middle portion of the watershed from northern margin to southern margin. From this zone, the variability increases towards southwest and as well as northeast. From here, the variability decreases towards east along the lower valley portion until touches Coimbatore city. During this season, the rainfall variability lies within 40-60% which indicates less in its fluctuation. From the foregoing facts and figures, it is inferred that the variability fluctuation is less which ranges between 60-80% during both monsoon seasons, though summer touches the maximum of 118.2%.

However summer rain is useful for preparation of land for agricultural activities and summer ploughing before sowing and seedling. In continuation of summer rainfall, the southwest and northeast monsoon rains are main causes for agricultural activities as the fluctuation of variability is less than interior part of Tamil Nadu.

Therefore, the dependability for agricultural activities is relatively large during southwest and northeast monsoon seasons. Fig no.9 illustrates the north monsoon variability.
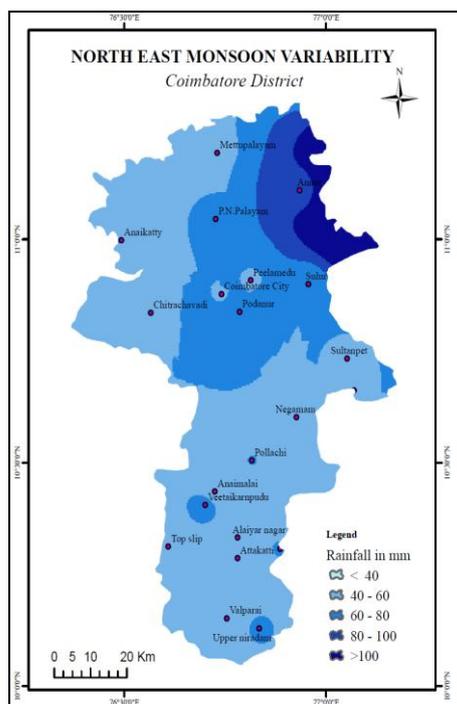

Fig 10 The northeast monsoon variability

Conclusion

The present study reveals that the use of GIS in spatial analysis for rainfall variability analysed both spatial and temporal distribution of rainfall and its patterns, both annually and seasonally. The seasonal distribution of rainfall for 33 stations in Coimbatore district is graphed to analyze the seasonal regime. All the 33 rain gauge station locations are mapped using GPS and GIS technique. Variation in annual total rainfall for 33 stations is calculated and isolines are drawn on the map. The annual rainfall for 33 stations is classified into three categories by using percentage criterion and evaluated by determining the abnormal condition for each station, and annual total rainfalls are plotted. It is also identified that topography plays an important role in the variability of rainfall. It is found that rainfall is lowest in mid of Coimbatore district and increases away from it in all directions from the Northeast monsoon season and South west monsoon seasons. The trends in spatial distribution of rain days are similar to that of the rainfall. The long term mean annual rainfall of the district is about 639 mm of which the winter, summer, southwest and northeast monsoon contribute 1.9, 18.9, 44.7 and 34.5 of the annual rainfall respectively.

The seasonal or temporal rainfall distribution is of vital importance in human activities especially in agriculture and is a decisive factor in the struggle for sufficient food supply as agricultural activities each year are regulated according to its behaviour. According to the coefficient of variation, the lowest annual variability in rainfall is observed at Bhavani sagar 21.21% and the mid portion of the study area Coimbatore city with a value of 49.90. The highest variability is found in the core area of the region with a value of more than 53.37 per cent at Mettupalayam.

The rainfall variability is greatest in the central area and it decreases away from it in all directions. Low variability implies that the mean rainfall at a given location is reliable while high variability implies wide fluctuations about the mean value. Generally, it is obvious that there is an inverse relationship between rainfall amount and rainfall variability. Annual rainfall is most variable in all the seasons. This is critical as it is the Bhavanisagar, Aliyanagar, Valparai that receives least rain and records highest variation, thus making it very vulnerable in terms of crop production. The study concludes that the Coimbatore district receives meager amount of rainfall over the last twenty years.

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