



ANALYSIS OF RAINFALL VARIATION USING GIS: THE AMBULIYAR WATERSHED, TAMIL NADU, INDIA

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ABSTRACT

Among the climatic elements, the rainfall is the first index, ever thought of by farmers and climatic analysers as it is the most important single factor, which determines the cropping pattern of an area in general, the type of crop to be cultivated and its success or failure in particular. Therefore, the present study deals the rainfall characteristics of the Ambuliyar watershed, which includes the spatial distribution and its variability through different seasons. The study was used 30 years (1984 to 2013) monthly rainfall data for 10 rain gauge stations. The long term average annual rainfall of the study area is 740.33 mm, of which the winter, summer, southwest and the northeast monsoons were recorded 41.49 mm, 77.69 mm, 230.79 mm and 390.35 mm respectively. Aranthangi rain gauge station was received the highest rainfall of 1017.45 mm whereas Neidavasal rain gauge station was recorded the lowest rainfall of 558.61 mm. The mean annual rainfall variability ranges from 35.91 per cent at Nagudi rain gauge station to 150.98 per cent at Neidavasal rain gauge station. The east and the southwest parts of the study area experiences heavy rainfall whereas the minimum rainfall was recorded in the north part of the study area.

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INTRODUCTION

Rainwater is also called precipitation and it is a natural feature of the earth's weather system. Its very presence in the atmosphere provides for a type of direct evaporation that replenishes the moisture and heat in cloud systems. Three main characteristics of rainfall are very necessary such as, amount, frequency and intensity, the values of which vary from place to place, day to day, month to month and also year to year. Exact knowledge of these three main characteristics is indispensable for planning and its full utilisation. India is a tropical country, its agricultural planning and utilisation of water is depends on monsoon rainfall, more than 75 per cent of rainfall occurring during the monsoon season. Monsoon rainfall is uneven both in time and space, so it is important factors to evolving the rainfall analysis. Rainfall distribution pattern is the most imperative factor, as the distribution of rainfall varies over space and time, it is required to analyse the data covering long periods and recorded at various locations to acquire dependable information. Mainly the heavy rainfall

occurs during the monsoon season and when the rainfall during the monsoon season is unequal both in time and space so it is significant to analyse the rainfall variation. Rajapange and Wani (2011) have conducted a geographical study of rainfall distribution in Beed district (Maharashtra). Uduak, Udo-Inyang and Edem (2012) have studied the analysis of rainfall trends in Akwa Ibom State, Nigeria. Neeraj Bhargava1, *et al.*, (2013) have conducted a study on the rainfall spatial analysis using GIS. Shiulee Chakraborty, Pandey and Chaube, Mishra (2013) have studied about the trend and variability analysis of rainfall series at Seonath River Basin, Chhattisgarh (India). Scott Lincoln (2014) has analysed 15th June 2013 isolated extreme rainfall event in Springfield, Missouri. Umar, Bibi, Kaduk and Balzter (2014) have analysed the spatial temporal variation and prediction of rainfall in the northeastern Nigeria. Diouf, Sambou, Traore, Ndiaye, Chaibo, Sambou, Diaw and Beye (2016) have conducted a study on the frequency analysis and exploratory of rainfall variability in Bounkiling river basin in a context of climate change and variability. Peleg, Blumensaatt, Molnar,

Fatichi and Burlando (2016) have investigated the partitioning spatial and temporal rainfall variability in urban drainage modeling. Schmidt, Alewell, Panagos and Meusburger (2016) have conducted a study on regionalisation of monthly rainfall erosivity patterns in Switzerland. Senadeera, Wanniarachchi and Rathnayake (2016) have analysed the rainfall analysis in Uma Oya basin, Sri Lanka. Atieh, Rudra, Gharabaghi and Lubitz (2017) have investigated the spatial and temporal variability of precipitation using entropy theory. Hence, the present study has been chosen to know the analysis of rainfall trends in the Ambuliyar watershed, Tamil Nadu, India.

from Public Works Department, Taramani, Chennai. Ten rain gauge stations (in and around the study area) have been taken into consideration for calculating long term mean monthly, seasonal and annual rainfall pattern and these have been analysed. The coefficient of variability was worked out to know about the variability of rainfall in the study area. The collected rainfall data has been processed and analysed by using GIS software and relevant maps have been prepared using the same software.



Study Area

The Ambuliyar watershed lies in the districts of Thanjavur and Pudukkottai in the State of Tamil Nadu. It is partly in the central part of Thanjavur district and partly eastern part of Pudukkottai district. It is located between the latitudes 79° 0' E and 79° 10' E longitudes and 10° 10' N and 10° 20' N latitudes. Ambuliyar watershed covers the total area of 702.03 km² (Fig. 1). It is bounded between Pudukkottai district in the west, Thanjavur district in the east and Palk Strait in the southeast. Thanjavur and Pudukkottai districts form the northern limit and Pudukkottai and Thanjavur district set the southern limits. The watershed is linear in shape and runs roughly in a NW-SE direction for 29 km and ends in the Palk Strait in the southeast direction. Its widths vary between 15 and 34 km. The maximum width is along the line connecting 28 km in NW to SW direction. Physiographically the watershed is flat with gentle slope. Geological formations are ranging in age from Archaean to recent.

Methodology

The base map has been prepared from the Survey of India Topographic sheets on 1:50,000 scale (Topographic sheets 58 J/15, J/16, 58 N/3, N/4, N/7 and N/8). Monthly rainfall data for the period of 30 years from 1984 to 2013 has been collected

RESULTS AND DISCUSSION

Rain Gauge Stations: Ten rain gauge stations rainfall have been taken to analyse the spatial distribution and its characteristics of the study area (Table 1 and Fig. 2).

Table 1. Rain Gauge Stations

Sl. No.	Rain Gauge Stations
1.	Alangudi
2.	Aranthangi
3.	Arimalam
4.	Karambakudi
5.	Kattumavadi
6.	Nagudi
7.	Neidavasal
8.	Peravoorani
9.	Perungalur
10.	Pudukottai

Source: Public Works Department, Chennai

Mean Annual Rainfall

Mean annual rainfall varies from 558.61 mm (Neidavasal) to 1017.45 mm (Aranthangi). Both the rain gauge stations are located in the north and the south parts of the study area respectively. More than 900 mm mean annual rainfall was recorded in two rain gauge stations namely Aranthangi

Table 2. Seasonal and Annual Mean Rainfall (1984-2013)

Sl. No.	Rain Gauge Station	Winter	Summer	Southwest	Northeast	Mean Annual
1.	Alangudi	35.69	69.58	257.31	358.90	721.48
2.	Aranthangi	55.54	89.74	347.52	524.65	1017.45
3.	Arimalam	38.20	79.58	286.08	380.87	784.73
4.	Karambakudi	48.90	62.82	193.27	376.48	681.47
5.	Kattumavadi	61.05	122.42	189.28	499.49	872.25
6.	Nagudi	56.39	75.89	187.50	390.56	710.34
7.	Neidavasal	15.51	47.42	105.05	390.62	558.61
8.	Peravoorani	71.75	105.38	250.76	522.10	949.99
9.	Perungalur	34.95	97.23	328.19	405.68	866.05
10.	Pudukottai	35.34	90.38	336.41	362.26	824.39
	Total	41.49	77.69	230.79	390.35	740.33

Source: Compiled by the Authors

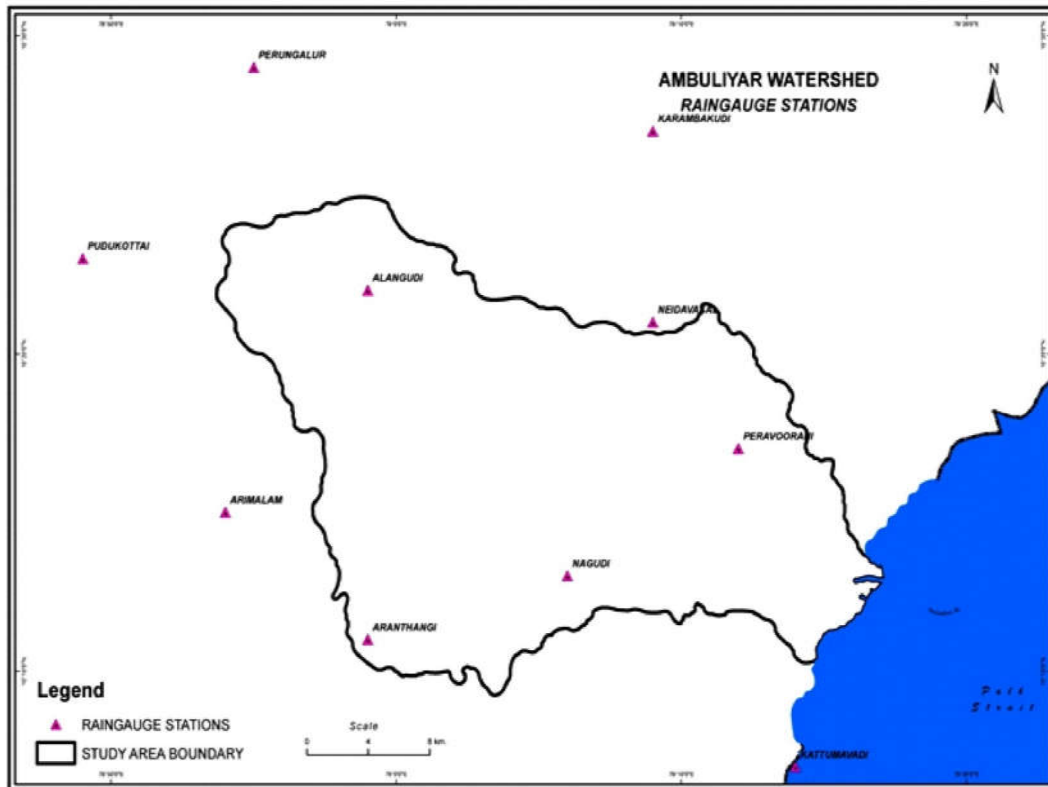


FIG.2

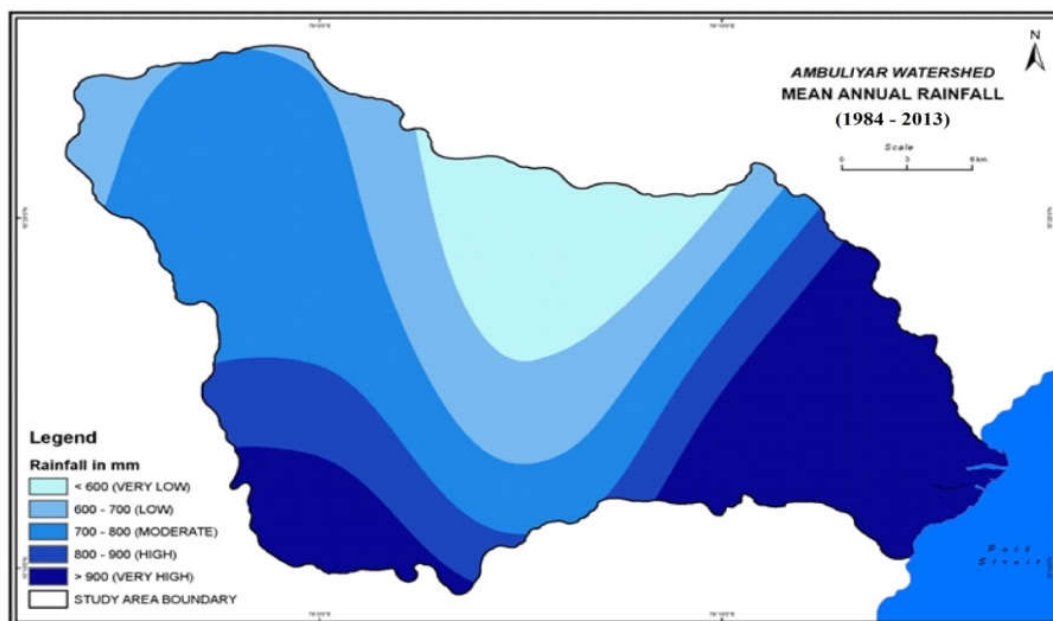


FIG.3

(1017.45 mm) and Peravoorani (949.99 mm), which are located in the southwest and northeast parts of the study area respectively (Table 2). These areas experience heavy rainfall during the period. This much amount of rainfall was recorded in the south, southeast, east and the northwest parts of the study area (Fig. 3). Only three rain gauge stations (Kattumavadi, Perungalur and Pudukkottai) were received the high mean annual rainfall (800 mm to 900 mm), which are located in the southeast, northwest and northwest parts of the study area respectively. Low mean annual rainfall (600 mm to 700 mm) was recorded only in Karambakudi rain gauge station, which is located in the north part of the study area. The north part of the study area experiences low and very low mean annual rainfall during the period. Mean annual rainfall gradually increases towards south and the east of the study area. A continuous stretch of low mean annual rainfall runs from the northeast to central and northwest part of the study area and another one small portion of low mean annual rainfall has been found in the northwest part. Very low mean annual rainfall (below 600 mm) was recorded in Neidavasal rain gauge station, which is located in the north part of the study area (Fig. 3).

Mean Seasonal Rainfall

Winter Season

The winter season begins after the retreating of the northeasterly winds. Winter season starts by January and ends by February, at the time of the year the days are cold. During the season, winter rainfall varies from 15.51 mm (Neidavasal) to 71.15 mm (Peravoorani). Very high winter rainfall (more than 55 mm) has been found as a continuous stretch runs from the northeast to east, southwest and the south parts of the study area. High winter rainfall (45 mm to 55 mm) has been noticed as a continuous stretch runs from the northeast to the southwest part and only one rain gauge station namely Karambakudi falls in this category. These areas experience heavy rainfall during the period (Fig. 4). Moderate amount of rainfall (35 mm to 45 mm) has been found as a continuous stretch runs from the northeast to the southwest part of the study area. Three rain gauge stations (Alangudi, Arimalam and Pudukkottai) were received moderate amount of rainfall. Winter rainfall gradually decreases towards west, northwest, north and the northeast parts of the study area. Low amount of rainfall (25 mm to 35 mm) has been noticed in the central and the northwest part (only Perungalur rain gauge station) of the study area. Very low rainfall was recorded in Neidavasal rain gauge station (15.51) mainly in the central part of the study area.

Summer Season

Summer season starts by March and ends in the month of May. Summer season varies from 47.2 mm (Neidavasal rain gauge station) 122.42 mm (Kattumavadi rain gauge Station). Very low amount of rainfall (47.42 mm at Neidavasal rain gauge station) has been noticed in the north part of the study area. Low rainfall (50 mm to 70 mm) has been found as a single stretch runs from the northwest to central to the northeast parts (Alangudi and Kattumavadi rain gauge stations) of the study area. These areas experience low summer rainfall during the period (Fig. 4). Moderate rainfall (70 mm to 90 mm) has been observed as a single stretch runs from the northwest, west, southwest, south to northeast parts (Aranthangi, Arimalam and

Nagudi rain gauge stations) of the study area. Summer rainfall gradually increases towards the northeast, east and southeast parts of the study area. High amount of rainfall (90 mm to 110 mm) has been found in two different places, one is as a small pocket occurs in the southwest part and another one stretch is in the south to the northeast parts (Peravurani - 105.38 mm, Perungalur - 97.23 mm and Pudukkottai - 98.38 mm) of the study area. Very high rainfall (more than 110 mm) has been noticed in the northeast (Kattumavadi - 122.42 mm) part and it occurs as a single stretch.

Southwest Monsoon

India gets major parts of its rainfall during this season. June, July, August and September form core of the southwest monsoon in almost all parts of the country. Southwest monsoon rainfall varies from 105.05 mm (Neidavasal) to 347.52 mm (Aranthangi) (347.52 mm). Very high southwest monsoon rainfall (more than 300 mm) has been found in two different places, one is located in the southwest and another one occurs in the east (Aranthangi - 347.52 mm, Perungalur - 328.19 mm and Pudukkottai - 326.41 mm) respectively. These areas experience heavy rainfall during the period. High rainfall (250 mm to 300 mm) has been found in the northeast, west, southwest parts (Alangudi - 257.31 mm and Peravurani - 250.76 mm) of the study area (Fig. 4). Moderate rainfall (200 mm to 250 mm) has been found as a single stretch in the northwest, west, south, east and the northeast parts. Low rainfall (150 mm to 200 mm) has been found as a single stretch in the north, south to the northeast parts (Karambakudi - 193.27 mm, Kattumavadi - 189.28 mm and Nagudi - 187.50 mm) of the study area. Very low rainfall (less than 150 mm) has been observed in the north part of the study area. Southwest monsoon rainfall gradually decreases towards the central and north parts of the study area. Rainfall gradually decreases towards north of the study area.

Northeast Monsoon

The northeast monsoon is very active during the months of October, November and December. The northeast monsoon rainfall varies from 358.90 mm at Alangudi to 526.65 mm at Aranthangi rain gauge stations, which are located in the northeast and the southwest parts respectively. Very low rainfall (less than 370 mm) has been noticed as a single stretch in the northeast, central and the north parts (Alangudi - 358.90 mm and Pudukkottai - 363.26 mm) of the study area. Low rainfall (370 mm to 420 mm) has been found in the west, south, northeast parts mainly it occurs in five rain gauge stations (Arimalam - 380.87 mm, Karambakudi - 376.48 mm, Nagudi - 390.56 mm and Perungalur - 405.68 mm). Generally, these areas have low rainfall during the northeast season. Moderate amount of rainfall (420 mm to 470 mm) has been observed in two different places (Fig. 4). One is located in the southwest and another one occurs is occurred in the south and the northeast parts. High amount of rainfall (470 mm to 520 mm) has been found in Kattumavadi rain gauge station only, which is located away from the study area mainly in the coastal stretch. Very high amount of rainfall (more than 520 mm) has been identified in the southwest part (Aranthangi - 524.65 mm) and the northeast part (Peravurani - 522.10 mm) of the study area respectively. Northeast monsoon rainfall gradually increases in the northeast, east, southeast and the south parts of the study area.

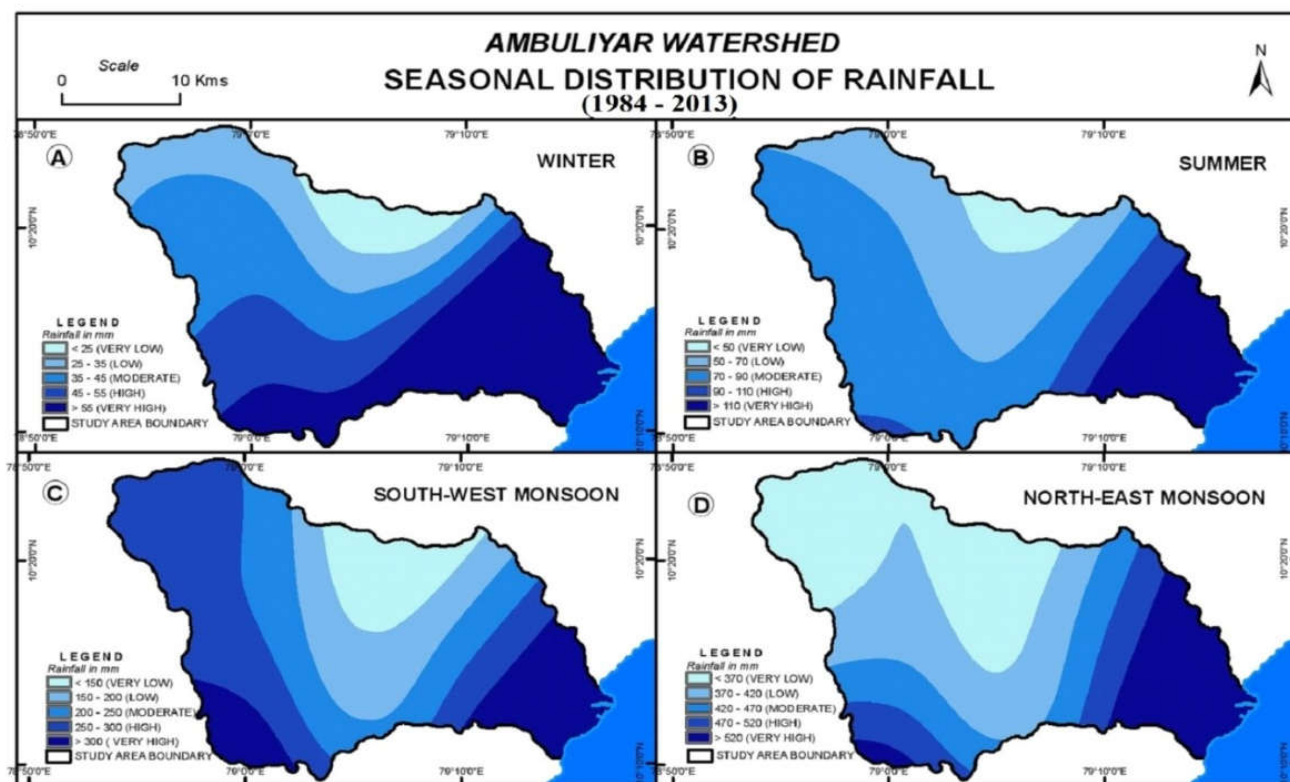


FIG.4

Table 3. Seasonal and Annual Rainfall Variability (Per cent)

S.No.	Rain Gauge Station	Winter	Summer	Southwest	Northeast	Mean
1.	Alangudi	146.02	97.83	38.70	52.80	38.83
2.	Aranthangi	165.51	72.42	43.99	60.84	38.53
3.	Arimalam	194.79	90.50	58.79	55.30	48.21
4.	Karambakudi	185.69	108.50	81.47	67.34	64.57
5.	Kattumavadi	139.14	91.61	52.94	59.20	37.50
6.	Nagudi	170.03	69.93	48.89	42.96	35.91
7.	Neidavasal	217.52	194.44	187.94	152.49	150.98
8.	Peravoorani	145.22	69.81	43.55	57.13	36.25
9.	Perungalur	176.81	82.06	40.46	45.98	42.23
10.	Pudukkottai	156.68	78.55	51.44	56.33	30.40

Source: Compiled by the Authors

Variability of Rainfall

Variability 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. The following table shows that the formula has been applied to find out the variability of the seasonal and annual rainfall variability (Table 3).

Annual Rainfall Variability

Mean annual rainfall variability varies from 30.40 per cent (Pudukkottai) to 150.98 per cent (Neidavasal), which are located out of the study area mainly in the west and the north parts of the study area respectively. More than 120 per cent rainfall variability has been noticed as a single stretch in the north part of the study area. High rainfall variability (100 per cent to 120 per cent) has been found in the north part. These areas have more rainfall reliability during period. Moderate rainfall variability (80 per cent to 100 per cent) has been identified in the north part mainly Kalathur in the west and Keelathur in the east part of the study area (Table 3). Low rainfall variability (60 per cent to 80 per cent) has been noticed

as a single stretch from the northwest to central to northeast parts of study area. Karambakudi rain gauge station falls under this category. Very low rainfall variability (less than 60 per cent) has been absorbed in the northwest, west, southwest, southeast and northeast parts mainly Alangudi, Aranthangi, Arimalam, Kattumavadi, Nagudi, Peravurani, Perungalur and Pudukkottai rain gauge stations of the study area (Fig. 5).

Winter Rainfall Variability

Winter rainfall variability varies from 139.14 per cent (Kattumavadi) to 217.52 per cent (Neidavasal), which are located in the southeast part and north part of the study area respectively. Very high rainfall variability (more than 20 per cent) has been found as a small pocket in the north part of the study area. These areas have more rainfall reliability during the period. High rainfall variability (190 per cent to 210 per cent) has been seen in the north part (Arimalam rain gauge station) of the study area (Fig. 6). Moderate rainfall variability (170 per cent to 190 per cent) has been noticed in two different places. One stretch is located in the north, south and to the northeast parts and another one stretch has been found in the southwest part nearby Kammankadu and Chitthanavasal villages in the south.

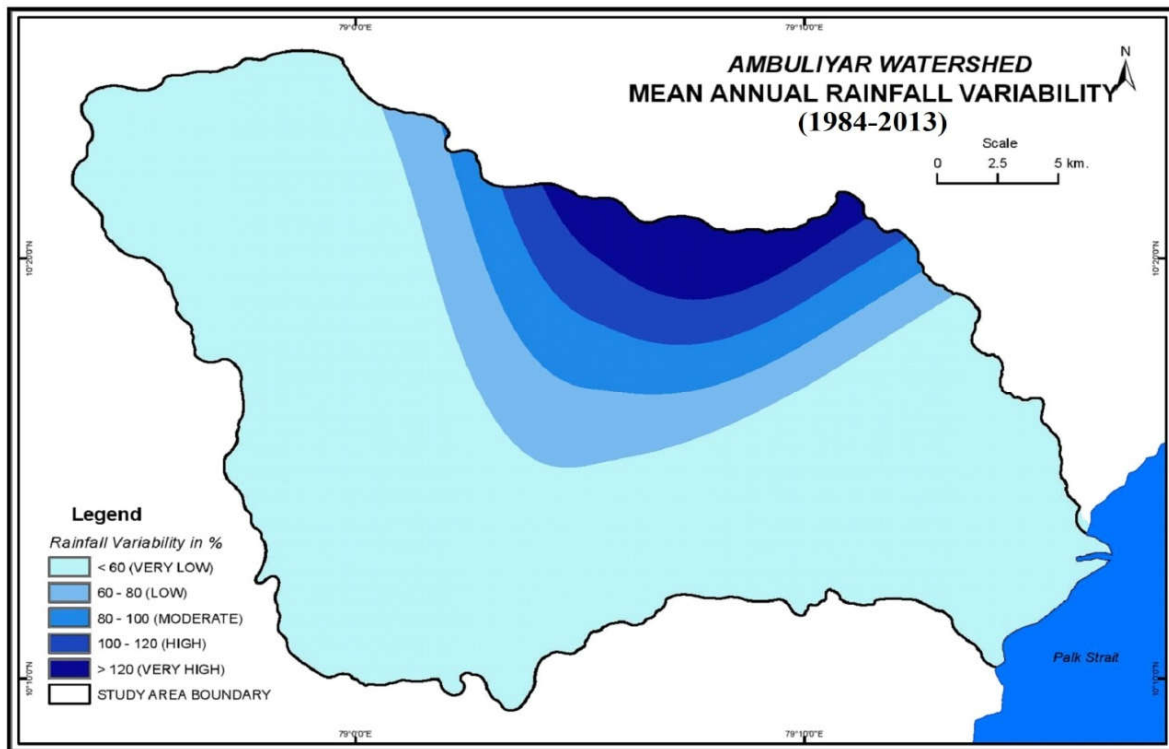


FIG.5

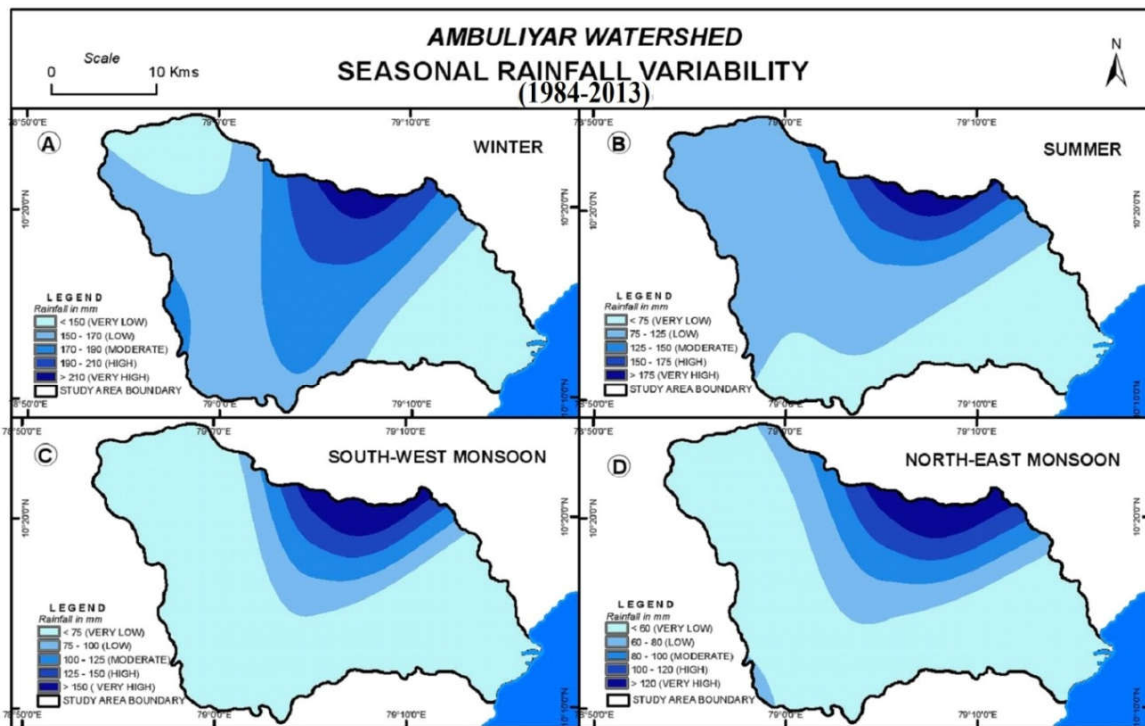


FIG.6

Three rain gauge stations namely Karambakudi, Nagudi and Perungalur have moderate rainfall reliability during the season, which is located Karambakudi in the north, Nagudi in the south and Perugalur in the northwest part of the study area. Among these rain gauge stations, Nagudi is located within the watershed. Low rainfall variability (150 per cent to 170 per cent) has been noticed as a single stretch in the northwest, west, south and the northeast parts of the study area. Two rain gauge stations namely Aranthangi and Pudukkottai have low rainfall reliability during the season. Less than 115 per cent of rainfall variability has been found in two pockets of the study area, which are located in the northwest and the southeast parts

respectively. Only three rain gauge stations (Alangudi, Kattumavadi and Peravurani) have very low reliability during the season.

Summer Rainfall Variability

Summer rainfall variability varies from 38.70 per cent (Alangudi) to 189.94 per cent (Neidavasal). Very low rainfall variability (less than 75 per cent) has been identified as a single stretch in the southwest and the northeast parts of the study area. Two rain gauge stations namely Aranthangi (72.42 per cent) and Peravurani (69.81 per cent) have very low rainfall variability during the season. These rain gauge stations

have more rainfall reliability during the season and also period. Low rainfall variability (75 per cent to 125 per cent) has been noticed as a single stretch in the northwest, west, centre and the northeast parts of the study area. Five rain gauge stations namely Alangudi (97.83 per cent), Arimalam (90.50 per cent), Kattumavadi (91.61 per cent), Perungalur (82.06 per cent) and Pudukkottai (78.55 per cent) have low rainfall reliability during the season (Table 3). Moderate rainfall variability (125 per cent to 150 per cent) has been seen as a single stretch in the north part of the study area. High rainfall variability (150 per cent to 175 per cent) has been found in the north part of the study area. Very high rainfall variability (more than 175 per cent) has been identified as a small pocket in the north part of the study area (Fig. 6).

Southwest Monsoon Rainfall Variability

Southwest monsoon rainfall variability varies from 38.70 per cent (Alangudi) to 187.94 per cent (Neidavasal), which are located in the north and northeast parts of the study area respectively. Very high rainfall variability (more than 150 per cent) has been noticed as a single stretch in the north part of the study area. High rainfall variability (125 per cent to 150 per cent) has been found as a single stretch in the north part of the study area. These areas have more rainfall reliability during the season. Moderate Rainfall variability (100 per cent to 125 per cent) has been seen in the above north part of the study area (Fig. 6). Low rainfall variability (75 per cent to 100 per cent) has been identified as a single stretch in the northwest, central, northeast part of the study area. During the season, maximum area of the study area has very low rainfall variability (less than 75 per cent).

Northeast Monsoon Rainfall Variability

Northeast monsoon rainfall variability differs from 45.98 per cent (Perungalur) to 152.49 per cent (Neidavasal). Very low rainfall variability (less than 60 per cent) has been found as a single stretch in the northwest, west, southwest, southeast and east part of the study area. Seven rain gauge stations namely Alangudi (52.80 per cent), Arimalam (55.30), Kattumavadi (59.20 per cent), Nagudi (42.96), Peravurani (57.13 per cent) and Perungalur (45.98 per cent) and Pudukkottai (56.33 per cent) have very low rainfall reliability during the season (Table 4). These areas experience heavy rainfall during the season. Low rainfall variability (60 per cent to 80 per cent) have been found at two different places, a very small pocket is found in the southwest part and another one is a continuous stretch in the northwest, central and northeast parts of the study area. Moderate rainfall variability (80 per cent to 100 per cent) has been noticed in the north part of the study area. High rainfall variability (100 to 120 per cent) has been identified in the north part of the study. Very high rainfall variability (more than 120 per cent) has been observed in the north part of the study area. These areas experience very less rainfall during the season.

Conclusion

As far as mean annual rainfall is concerned, in the southwest, northeast, east and southeast parts of the study area experiences heavy rainfall during the period mainly Aranthangi and Peravoorani rain gauge stations. Mean annual rainfall gradually decreases towards the central, north and the northwest parts. During the winter season, in the south, southwest, northeast, east and the southeast part experiences

heavy rainfall. It is gradually decreases central, north and the northwest parts of the study area. Almost the same trend of has been noticed in the summer rainfall distribution during the period. During the southwest monsoon rainfall distribution, the study area has same trend of mean annual rainfall distribution. The study area was received more rainfall during the northeast monsoon season. The same southwest, northeast, east and southeast parts experience heavy rainfall distribution during the northeast monsoon season. As far as mean annual rainfall variability is concerned, central and north parts of the study area has more rainfall reliability during the period. The same trend of rainfall variability has been observed in southwest and northeast monsoon seasons. The central, west and northwest parts have low rainfall reliability during the winter and summer seasons. Generally, the study area receives more rainfall during the northeast monsoon season and also the south, northeast, east and the southeast parts of the study area receive more rainfall during the same season.

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