Research Article

A Statistical Analysis of Rainfall at South Uppar Odai Watershed of Amaravathi Basin

M. Angaleeswari*, A. Valliammai and A. Selvaperumal

Department of SWCE, Tamil Nadu Agricultural University, India

Abstract

Rainfall as one of the most important variable has a direct and indirect impact on the natural environment and human life. The study area of South Uppar Odai watershed falls under the catchment area of the Amaravathi river basin. Thiessen polygons were imposed on the base map to arrive at weighted mean rainfall for the entire study area. The probability analysis can be made by empirical or analytical methods. From the analysis of rainfall data of the rain gauge stations in South Uppar Odai watershed it was observed that there was a wide variation in annual rainfall over the years both spatially and temporally. The lowest annual rainfall recorded was 428.85 mm (2003) and the highest of 1134.55mm (2005) in the study area. The mean annual rainfall for the period 1982-2014 was calculated as 644.24 mm. The weighted mean rainfall distribution of South Uppar Odai watershed by Thiessan polygon method for 33 years (1982-2014) was estimated as 627.91 mm.

Keywords: Rainfall analysis, watershed, Thiessan polygon, statistical tool

***Correspondence**
Author: Angaleeswari
Email: eswarinaveenmani456@gmail.com

Introduction

The impacts of climate change and climate variability on human life have led the scientific community to monitor the behavior of weather and climate variables [1, 2]. Rainfall as one of the most important of these variables has a direct and indirect impact on the natural environment and human life [3]. A large spatial and temporal variability of rainfall leads to an increased incidence of extreme events such as floods and droughts. It is also recognized that rainfall is one of the key climatic variables that affect both the spatial and temporal patterns on water availability [4]. Moreover, erratic rainfall can trigger various disasters, for example, floods, landslides, water logging, erosion and salinity intrusion [5]. Every minor change in the rainfall intensity or amount imposes a severe challenge on the rural people since their main livelihood depends on agriculture which mostly relies on a short rainy season. Hence, the proper analysis of rainfall using statistical tool is important in studying the impacts of climate change and variability on water resource planning and management [6-8].

Materials and Methods

Description of the study area

The study area of South Uppar Odai watershed falls under the catchment area of the Amaravathi river basin. Geodetically, the study area is located 10^0 40’ 30”N to 10^0 45’ 30”N latitude and 77^0 15’ 00”E to 77^0 30’ 00”E longitude. The study area falls under the watershed codification of 4B2A7a2. The length of the area is about 18.5km and encompasses the watershed area of about 79.5 km^2. The river Uppar Odai flows into north east direction.

The scanned toposheet 58 F/6 at 1:50000 scale and the watershed map obtained from AED, Dharapuram covering the study area was used for base map preparation. The toposheet was georeferenced using the georeferencing toolbar in ArcGIS software environment and then the watershed map was georeferenced by getting the x, y co-ordinates from the georeferenced toposheet following the method of image to image resampling. Later the study area boundary was digitized using the above maps and stored in shape file format.

Arithmetic mean

The arithmetic mean of a set of observations is equal to their sum divided by total number of observations. It is simply average of the values [9].

$$\mu = \frac{\sum_{i=1}^{n} Ai}{n} \quad (1)$$

where, μ is arithmetic mean, Ai is sum of all numbers and n is total number of observations.

Thiessen polygons

Thiessen polygons were imposed on the base map to arrive at weighted mean rainfall for the entire study area. The Thiessen polygon method assumes that the rainfall recorded at a station is representative of the area halfway to the stations adjoining it. Each station is connected to its adjacent stations by straight lines, the perpendicular bisectors of which form a pattern of polygons. The weighted average rainfall was calculated by dividing the sum of the products of station areas and rainfalls by the total area of all the stations.

Probability analysis of rainfall

The purpose of the frequency analysis of an annual series is to obtain a relation between the magnitude of the event and its probability of exceedance. The probability analysis can be made by empirical or analytical methods.

It is generally known that it is not possible to generate the long term data of rainfall or runoff obtained from historical records by experimentation every time. Therefore, any inference on probable future behavior of such events must be made by fitting an appropriate probability distribution function of the past data. Hence, the following procedure was adopted to evaluate the behavior of rainfall events. The most common and simple method of calculation is plotting position or ranking of data method. The Weibull's method was used to find the probability of occurrence of rainfall at different probability levels is given by

$$P = m / (n+1) \quad (2)$$

Where, P = Probability; m = rank of the matrix; n = number of years

Result and discussion

Average annual rainfall

There are two rain gauge stations viz. Dharapuram and Udumalapet in the watershed. Of these two stations, Udumalapet recorded the highest average annual rainfall of 667.17 mm and followed by Dharapuram recorded 621.3 mm. The rainfall analysis of the study area showed a wide variation in the average annual rainfall over the years (1982-2014). The maximum annual rainfall of 1134.55 mm occurred during the year 2005 while the year 2003 received the minimum annual rainfall of 428.85 mm. The average annual rainfall of the study area for the period 1982 to 2014 was worked out to be 644.24 mm.

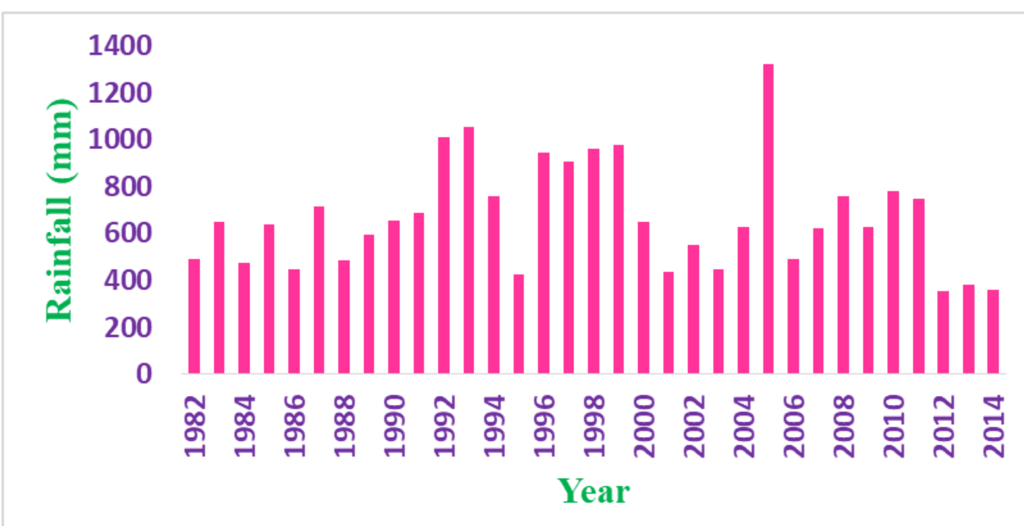

Figure 1 Annual rainfall of Udumalapet rain gauge station

In Udumalapet rain gauge station the maximum rainfall of 1321.70 mm occurred in the year of 2005 and the year 2012 received the minimum rainfall of 355.10 mm and shown in **Figure 1**. While Dharapuram rain gauge station received the maximum rainfall of 955.80 mm in the year of 2008 and the year 2003 received the minimum rainfall of 411.70 mm and shown in **Figure 2**.

Weighted mean rainfall

Using Thiessen polygon method the two rain gauge stations were found nearby the study area namely Dharapuram and Udumalapet which was has influence in the area that are shown in **Figure 3**. Of these two stations Udumalapet recorded the highest average annual rainfall of 667.17 mm followed by Dharapuram recorded as 621.31 mm. The weighted mean rainfall for the study area using Thiessan polygon method was worked out as 627.91 mm as the results obtained were more accurate than those obtained by simple arithmetic mean and given.

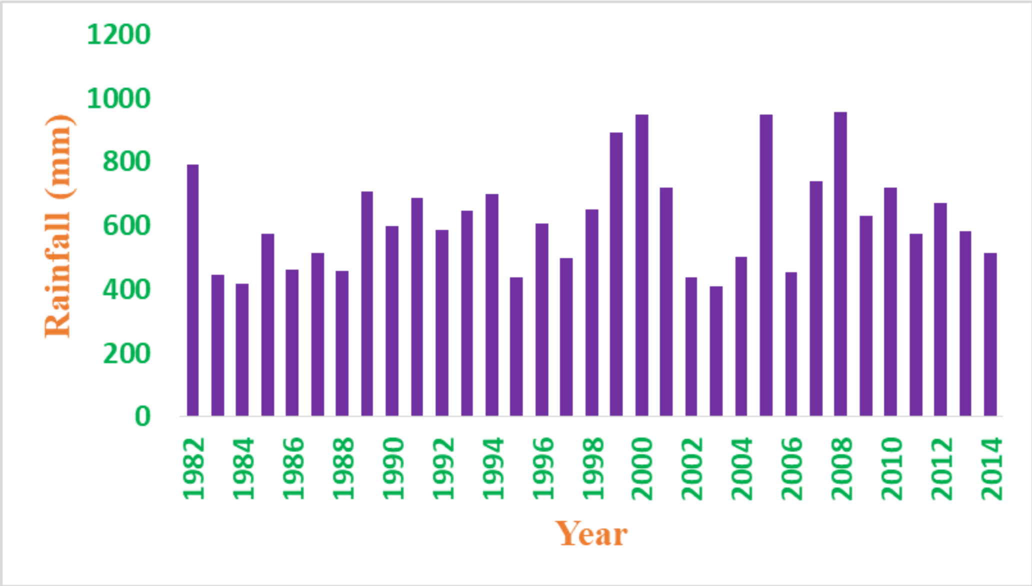

Figure 2 Annual rainfall of Dharapuram rain gauge station

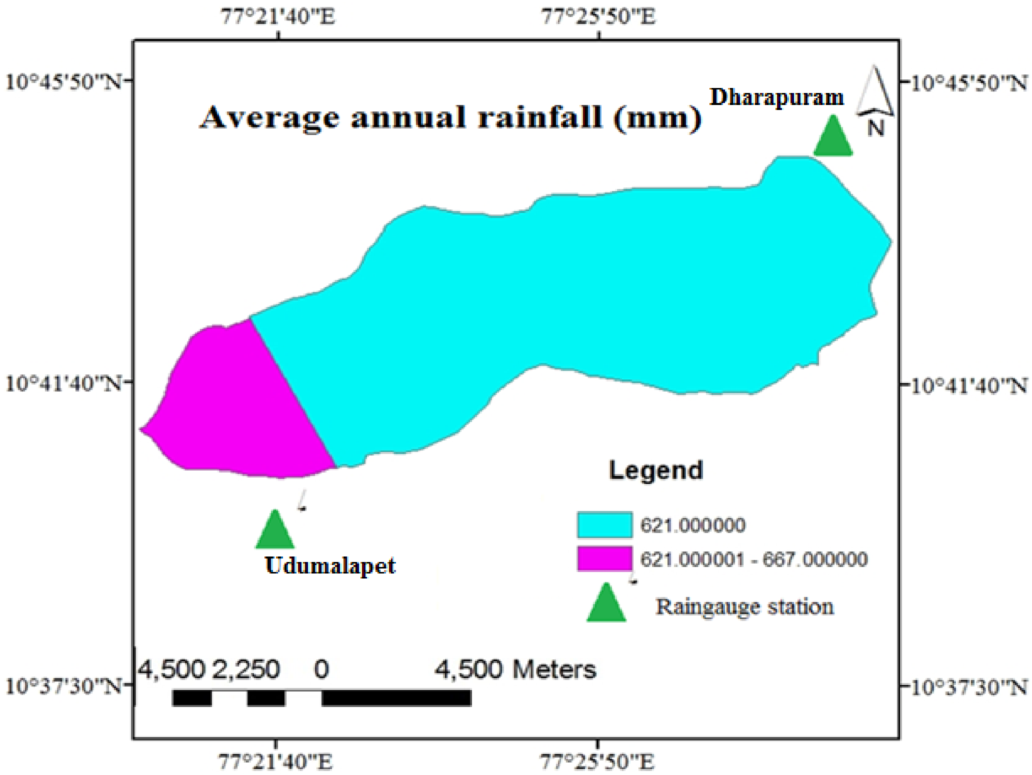

Figure 3 Thiessan Polygon map of the study area

Seasonal contribution of rainfall

Seasonal rainfall for the four season viz. South -West monsoon, North-East monsoon, Winter and Summer was presented. Average seasonal rainfall was calculated for the past thirty three years from 1982 to 2014 and represented graphically as shown in **Figures 4** and **5**. In the study area, North East monsoon contributed the maximum rainfall of 347.98 mm (54 per cent), followed by South West monsoon which contributed 172.53 mm (27 per cent), Summer which contributed 109.28 mm (17 per cent), and Winter contributed the minimum rainfall of 15.96 mm (2 per cent).

In the two rain gauge stations when the rainfall recorded from 1982 to 2014 was analysed, it was concluded that the contribution of North-East monsoon rainfall recorded higher seasonal rainfall compared to other seasonal rainfall. The average North East monsoon rainfall contributed to the study area was computed for both rain gauge stations and it was 402.07 mm (Udumalapet) and 290.86 mm (Dharapuram) respectively.

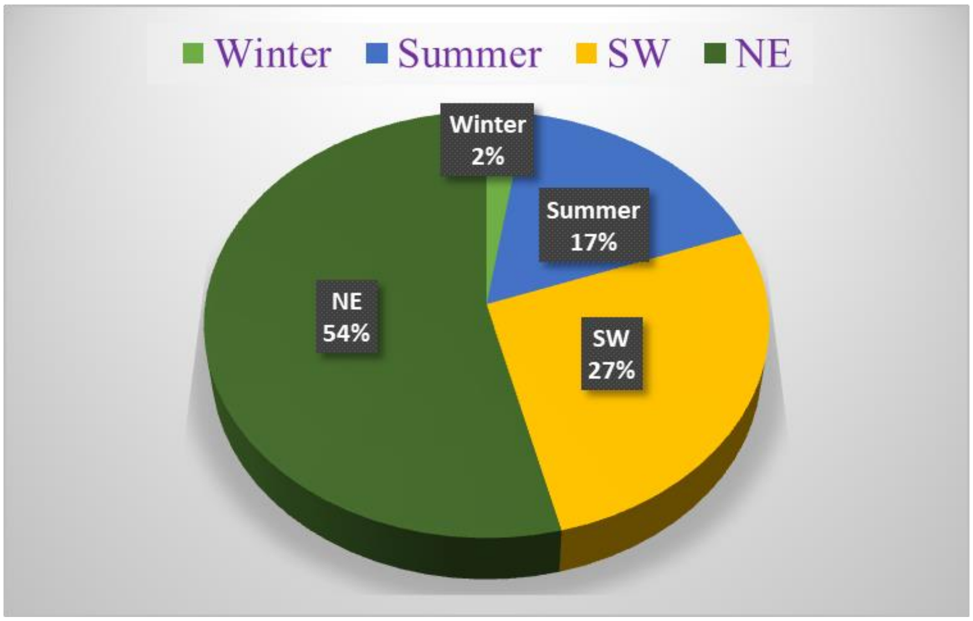

Figure 4 Seasonal distribution of rainfall of the watershed

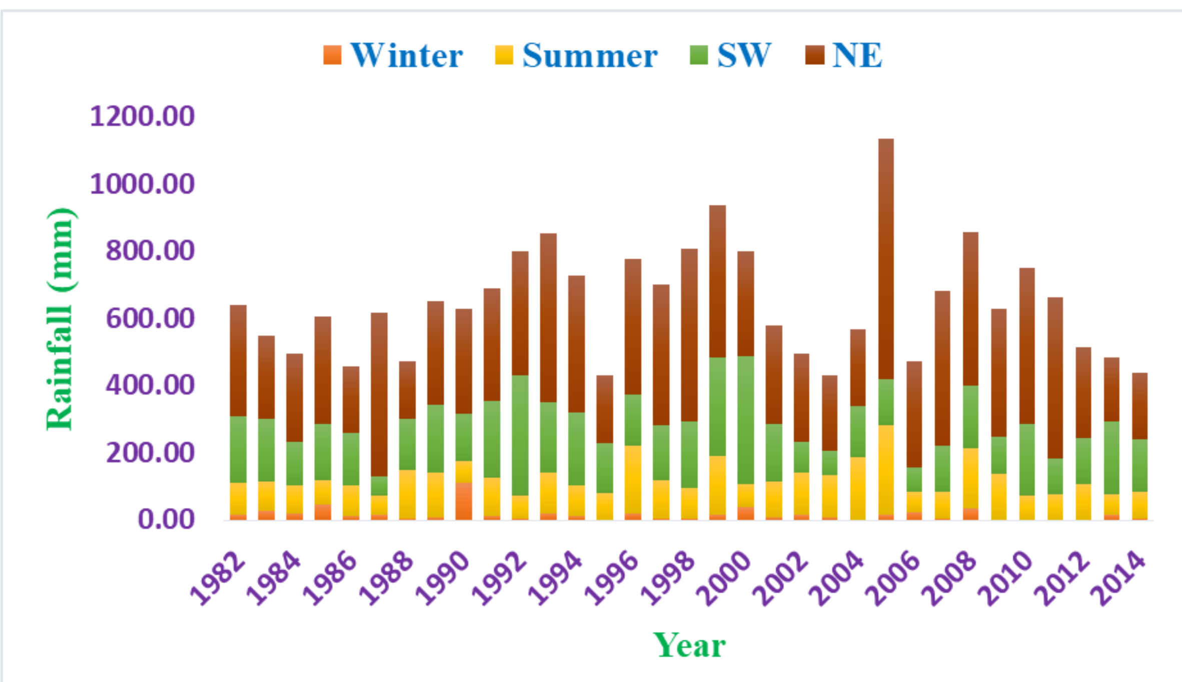

Figure 5 Temporal variation of seasonal rainfall

In Dharapuram region, the highest average seasonal rainfall contribution was 47 per cent in NE monsoon (Oct-Dec) followed by 35 per cent in SW monsoon (Jun-Sept) and 15 per cent during Summer (Mar-May) and the remaining 3 per cent during Winter (Jan-Feb) represented graphically as shown in **Figure 6**.

In Udumalapet region, the highest average seasonal rainfall contribution was recorded in NE monsoon (Oct-Dec) of 60 per cent. The South West and Summer contributed 19 per cent of rainfall to the study area and remaining two per cent of rainfall was contributed during Winter shown in **Figure 7**.

Average monthly rainfall

The average monthly rainfall of the watershed was calculated for the years 1982 to 2014 and a plot was drawn between the months and the monthly average rainfall as shown in **Figure 8**.While analysing the average monthly rainfall of the watershed, October month received a maximum of 145.33 mm rainfall and February month received a minimum rainfall of 7.32 mm.

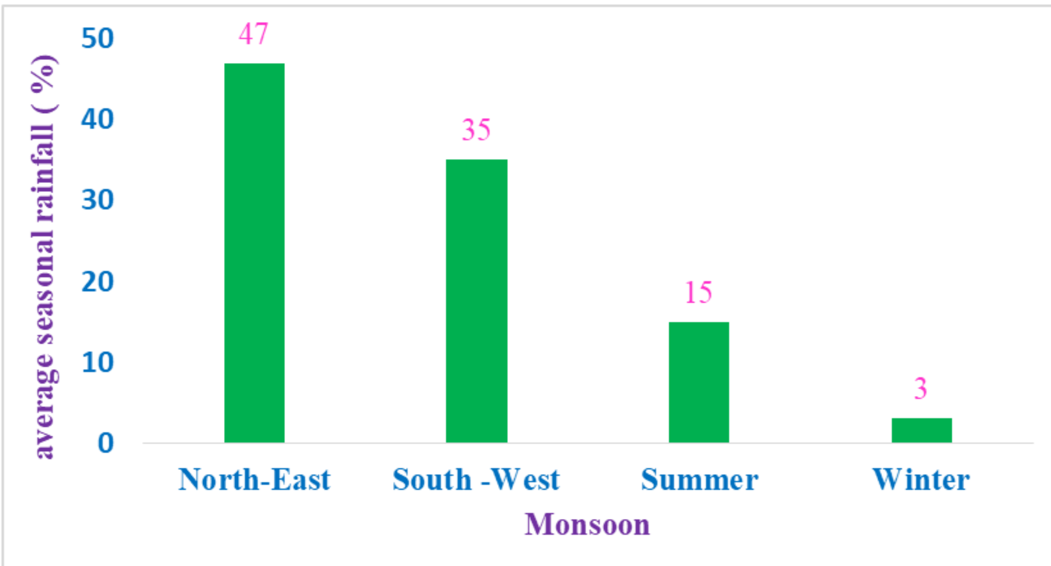

Figure 6 Average seasonal rainfall (percent) in Dharapuram rain gauge station

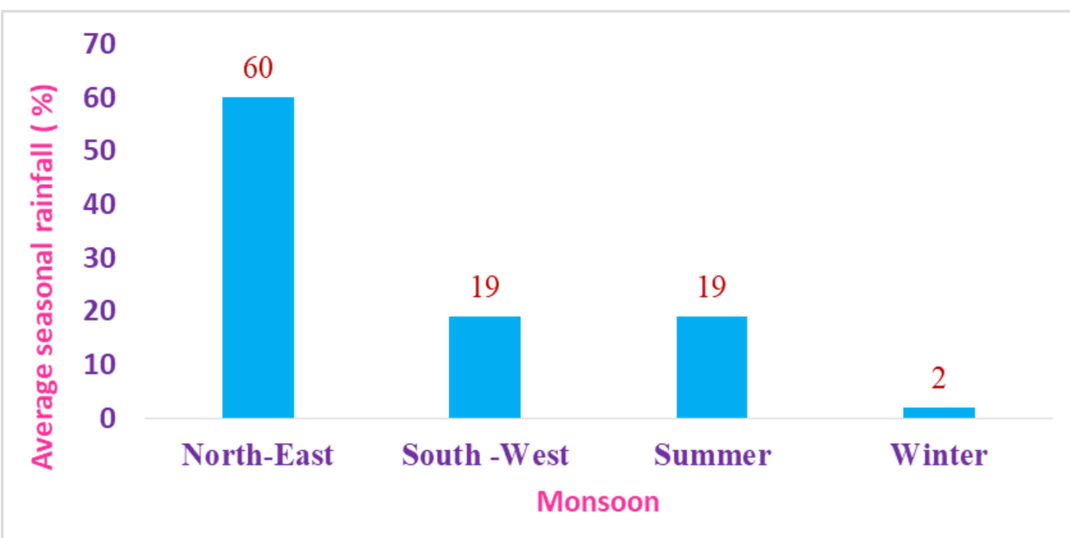

Figure 7 Average seasonal rainfall (%) in Udumalapet rain gauge station

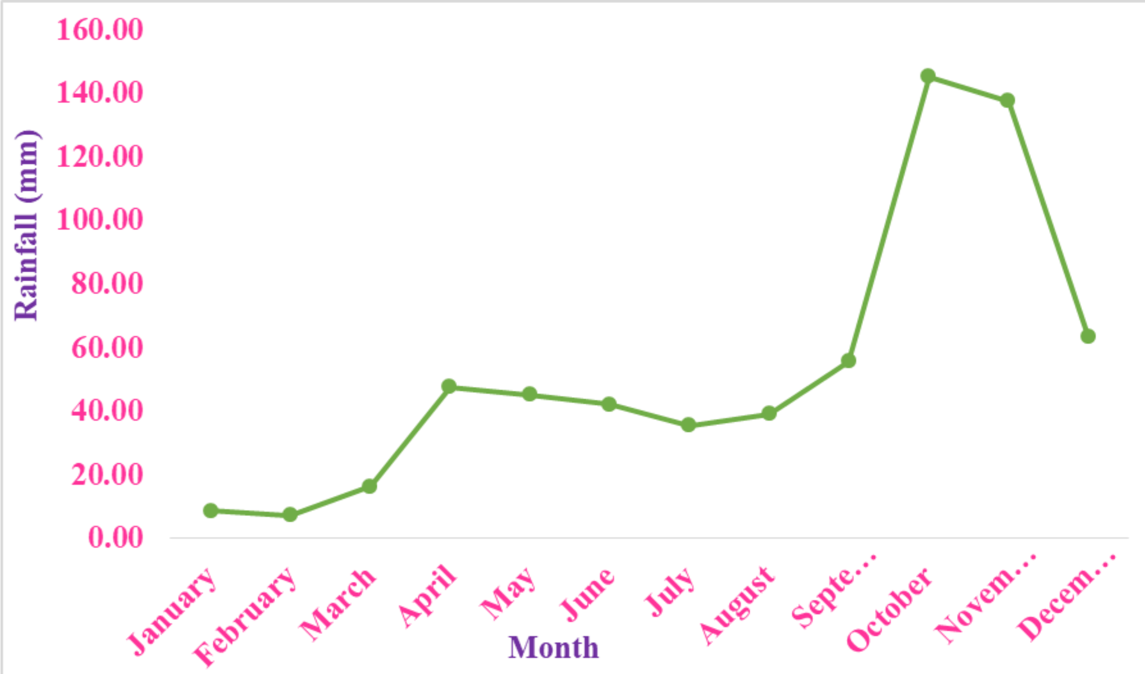

Figure 8 Average Monthly Rainfall of the watershed (1982-2014)

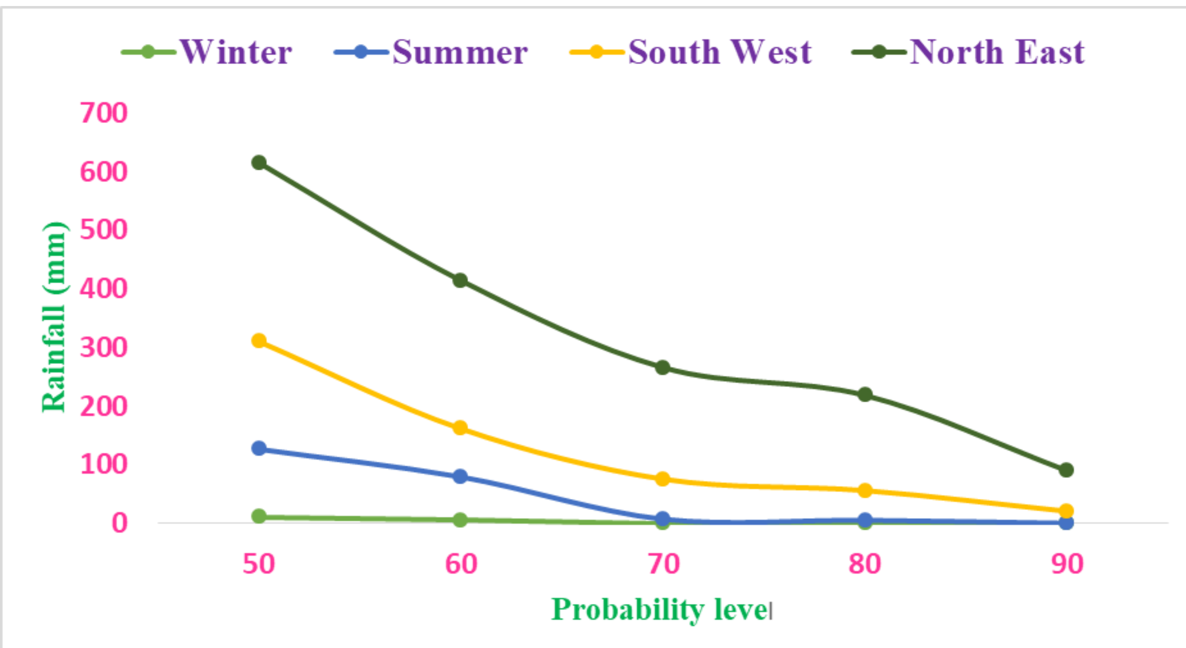

Figure 9 Seasonal rainfall at different probability levels

Probability Analysis

The annual and seasonal rainfall at probability levels of 50, 60, 70, 80 and 90 per cent were calculated by Weibull's method for the study area from 1982 to 2014. The annual rainfall at 50, 60, 70, 80 and 90 per cent probability levels was found to be 615.5, 414.2, 265.8, 218.4 and 89.6 mm respectively and shown **Figure 9**. The probability of rainfall during Winter (Jan-Feb) was almost nil and the highest in North East monsoon followed by South West monsoon.

The rainfall at 50 per cent chance can be considered as the maximum limit for taking any risk for water management studies [10] while the rainfall at 75 per cent probability can be safely taken as assured rainfall. Following the above criteria, the rainfall at 75 per cent probability levels for different seasons in the study area was worked out as 0 mm,5 mm, 57.5 mm and 175 mm. for Winter,Summer, South West and North East seasons respectively.

Conclusion

From the analysis of rainfall data of the rain gauge stations in South Uppar Odai watershed it was observed that there was a wide variation in annual rainfall over the years both spatially and temporally. The lowest annual rainfall recorded was 428.85 mm (2003) and the highest of 1134.55mm (2005) in the study area. The mean annual rainfall for the period 1982-2014 was calculated as 644.24 mm. The weighted mean rainfall distribution of South Uppar Odai watershed by Thiessan polygon method for 33 years (1982-2014) was estimated as 627.91 mm. The annual rainfall at 50, 60, 70, 80 and 90 per cent probability levels were 615.5 mm, 414.2 mm, 265.8 mm, 218.4 mm and 89.6 mm respectively. The rainfall at 75 per cent probability levels for different seasons in the study area was worked out as 315 mm, 126 mm, 29.1 mm and 1.1 mm for North-East, South-West, Summer and Winter seasons respectively. The study area received maximum average monthly rainfall of 145.33 mm during October and minimum average monthly rainfall of 7.32 mm during February. The area had four distinct seasons- Winter (Jan-Feb), Summer (Mar-May), South-West monsoon (Jun-Sept) and North-East monsoon (Oct-Dec). Statistically, the area received 54 per cent of annual rainfall during NE monsoon (Oct-Dec), 27 per cent during SW monsoon (Jun-Sept) and remaining 19 per cent during winter and summer (Jan-May).In the two rain gauge stations available in the study area, the contribution of North-East monsoon rainfall recorded higher seasonal rainfall compared to other seasonal rainfall. The highest North-East rainfall was recorded in Udumalapet (60per cent) followed by Dharapuram (47 per cent).

References

[1] Asfaw, A., Simane, B., Hassen, A. and Bantider, A. 2018. Variability and time series trend analysis of rainfall and temperature in northcentral Ethiopia: A case study in Woleka sub-basin. Weather and climate extremes. 19: 29-41.
[2] Bouklikha, A., Habi, M., Elouissi, A. and Hamoudi, S. 2021. Annual, seasonal and monthly rainfall trend analysis in the Tafna watershed, Algeria. Applied Water Science: 11(4): 1-21.
[3] Karnewar, K. V. 2018. Analysis of rainfall trends over Nanded of Maharashtra, India. International Journal of Research. 5(16): 571-581.
[4] Dashora, R., Dashora, Y., Sharma, U., Katara, P. and Patil, M. 2013. Development of Rainfall-Runoff Models for Gauged Micro Agricultural Watershed in Bhilwara District. In Proceedings of National Conference on Hydrology with Special Emphasis on Rain Water Harvesting. 15(6): 51
[5] Matsumoto, J. 1988. Synoptic features of heavy monsoon rainfall in 1987 related to the severe flood in Bangladesh. Bulletin of the Department of Geography, University of Tokyo. 20: 43-56.
[6] Arvind, G., Kumar, P. A., Karthi, S. G. and Suribabu, C. R. 2017. Statistical analysis of 30 years rainfall data: a case study. In IOP Conference Series: Earth and Environmental Science. 80(1): 012067. IOP Publishing.
[7] Praveen, B., Talukdar, S., Mahato, S., Mondal, J., Sharma, P., Islam, A. R. M. and Rahman, A. 2020. Analyzing trend and forecasting of rainfall changes in India using non-parametrical and machine learning approaches. Scientific reports, 10(1): 1-21.
[8] Touseef, M., Chen, L., Yang, K. and Chen, Y. 2020. Long-term rainfall trends and future projections over Xijiang River Basin, China. Advances in Meteorology.
[9] Dashora, R., Dashora, Y., Sharma, U., Katara, P. and Patil, M. 2013. Development of Rainfall-Runoff Models for Gauged Micro Agricultural Watershed in Bhilwara District. In Proceedings of National Conference on Hydrology with Special Emphasis on Rain Water Harvesting. 15(6): 51
[10] Gupta, V. K. and Duckstein, L. 1975. A stochastic analysis of extreme droughts. Water Resources Research. 11(2): 221-228.

Publication History

Received	21.06.2022
Revised	30.08.2022
Accepted	02.09.2022
Online	30.09.2022