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Analysis of Spatial and Temporal Rainfall Variations in Meenachil Basin

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***Abstract*--- This paper investigates the monthly, seasonal and annual rainfalls in the Meenachil Basin in Kerala using the data for the period, 2000 to 2019. The data from three rain gauge stations at Teekoy, Kozha and RRII, Puthupally, located in the highland, midland and lowland of the basin respectively, have been used for the study of spatial and temporal rainfall variations. It is found that the annual rainfall in the highland and midland show increasing trends, whereas a decreasing trend is observed in the lowland. It is a matter of concern that the slope of its trend line for highland is nine times that of midland. The South-West and North-East monsoons contribute to nearly 62% and 20% of the annual rainfall respectively. The average annual rainfall for this basin during the period of study is calculated by the Theisson polygon method using QGIS software and is obtained as 3216.5 mm, which is more than the normal rainfall of Kottayam as per IMD.**

***Keywords*--- Rainfall, Meenachil basin, trend, spatial and temporal variations**

I. INTRODUCTION

Meteorological studies play a key role in planning the developmental activities of a nation. Climate change involves changes in rainfall pattern, atmospheric temperature, pressure, wind speed and direction, etc. [1]. Rainfall is one of the important meteorological parameters which helps in the formation of the water management policies. This data is an essential component for water budgeting and modelling-based resources management for irrigation, power production, drinking water projects, etc. [2]. The temporal and spatial rainfall variations caused by climate change significantly affect the agricultural production and thus the GDP of the country. These variations are responsible for hydrological problems like flood and droughts [3].

The mean annual rainfall for Kerala state based on a study conducted for the period 1992 to 2012 is 2940.5 mm and shows a decreasing trend [4]. Also, the South-West (SW) and North-East (NE) monsoon rainfalls show a significant decreasing trend whereas the winter and summer rainfalls show an increasing trend. The rainfall decline is more predominant in June and July using the data for the period 1871 to 2005 [5]. In Pattambi, Kerala, the annual, SW and NE monsoon rainfalls for the period 1983 to 2017, show falling trends, whereas rising trend is observed for the months of April, May, September and October [6]. Analysis conducted using data of 33 stations of Muvattupuzha, Meenachil, Manimala, Pamba and Achenkovil river basins for the period 2001 to 2008, show that there is no significant correlation between elevation and rainfall [2].

This work analyses the spatial and temporal variations of annual, seasonal and monthly rainfalls in the Meenachil basin for the twenty-year period, from 2000 to 2019. The average rainfall of the basin is also calculated. The study reveals the possibility of increasing floods and droughts.

II. STUDY AREA

The study area chosen is Meenachil Basin which lies in Central Kerala and is bounded by the latitudes 9.45°N and 9.85°N and longitudes 76.4°E and 76.9°E. It has an area of 1243 sq. km and is surrounded by Muvattupuzha basin in the North, Periyar basin in the East and Manimala basin in the South. This area is nestled between the Western Ghats on one side and the Araabian Sea on other side. The 78.4 km long River Meenachil has its origin in the Wagamon hills. The river flows through important towns like Erattupetta, Pala, Kidangoor, Ettumanur and Kottayam and drains into Vembanad lake before emptying itself in the Arabian Sea. The basin map of river Meenachil is shown in Fig. 1.

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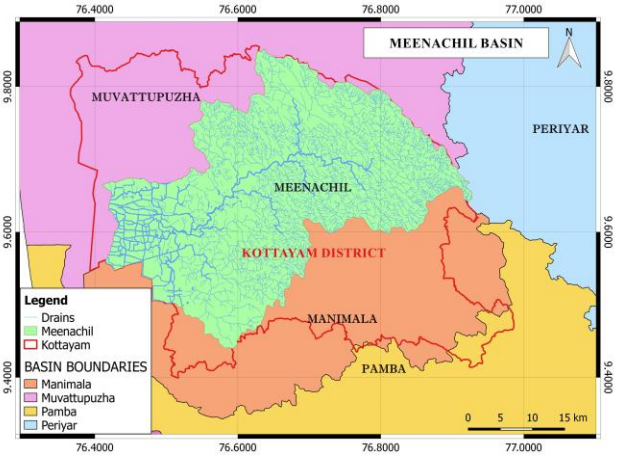

Fig. 1 Basin map of River Meenachil

Rainfall does not have a homogeneous spatial distribution. Topography is one of the important factors which dictates its spread and distribution. The elevation of the Meenachil basin varies from 1200 m to 1.1m above MSL. The topography of the basin can be divided into three zones (1) Highland (9.38%) (2) Midland (34.80%) and (3) Lowland (55.80%).

III. MATERIALS AND METHODOLOGY

There are seven rain gauge stations in the basin. Teekoy station is in the highland, Erattupetta and Kozha stations are in the midland whereas Velloor, Kottayam, Rubber Research Institue of India (RRII) Puthuppally and Kumarakom stations are in the lowland. Of these, three representative stations from the three terrains namely, Teekoy, Kozha and RRII, Puthupally are chosen for this study. The locations of these Meteorological gauge stations are shown in Fig. 2.

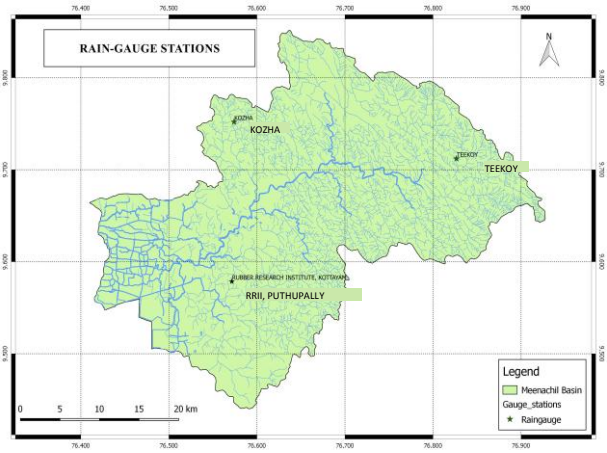

Fig. 2 Map showing rain-gauge stations in Meenachil basin

Data for twenty years spanning from 2000 to 2019 is collected from these representative rain-gauge stations in Meenachil basin. Annual, Seasonal and Monthly time series data of the three stations are analysed. Graphs are plotted to find the variability and trend of rainfall. In order to find the annual, seasonal and monthly average rainfall for the whole basin from the point rainfalls of the three rain gauges stations, Theisson polygon method has been adopted [3]. Each station is given a weightage on the basis of the area closest to the station. Using QGIS software, Theisson Polygon is drawn and areas are computed. Thus, the average rainfall of the Meenachil basin is calculated. The average monthly spread of rainfall for the period of study is also computed.

IV. RESULTS AND DISCUSSION

The time series data of annual rainfall for the three rain-gauge stations at Teekoy, Kozha and RRII, Puthupally are analysed using the data for the period 2000 to 2019. The relevant graphs are plotted and inferences are drawn.

A. Annual Rainfall

The lowest, highest and average annual rainfalls observed during the period of study in these three stations are given in Table I. In order to study the spatial and temporal variations of rainfall, the annual time series data is plotted as shown in Fig. 3.

Spatial Variation

It is observed from Table I that the highest annual average rainfall of 3769.6 mm is received in the highland Teekoy, whereas, the lowest of 2838.1 mm is in the lowland RRII, Puthupally. Twenty years of observation at Teekoy reveals that, there are sixteen years in which the annual rainfall exceeded 3000 mm (considered to the state annual rainfall), eleven times 4000 mm and once, the rainfall rose to 5714 mm (2018). At Kozha, rainfall exceeded 3000 mm ten times and 4000 mm only once. At RRII, Puthupally, rainfall greater than 3000 mm was obtained nine times. Thus, it is concluded that increased rainfall is obtained with increase in elevation in the Meenachil basin. This might be due to the orographic effect of rainfall.

Table I Lowest, highest and average annual rainfalls

Rain-Gauge Station	Annual rainfall (in mm)		
	Lowest	Highest	Annual Average
Teekoy	1787.8 (2004)	5714.0 (2018)	3769.6
Kozha	1787.6 (2016)	4004.1 (2018)	3012.4
RRII	1577.8 (2016)	3597.9 (2010)	2838.1

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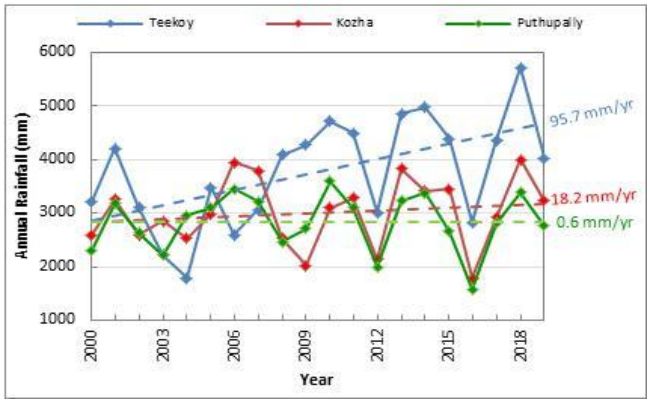


Fig. 3 Annual rainfall variation in Meenachil basin

Temporal Variation

From Fig. 3, it can be seen that the annual time series of all the three stations show an increasing trend during the twenty-year span. At Teekoy, there is a phenomenal increase in rainfall, with a trend line slope of 96 mm/year. The slope of the rainfall trend line at RRII, Puthupally is a meagre 0.6 mm/year. The slope of Teekoy is 5.25 times that of Kozha and 165 times that of RRII, Puthupally. Thus, it is concluded that the highland rainfall is considerably increasing with time.

B. Seasonal Rainfall

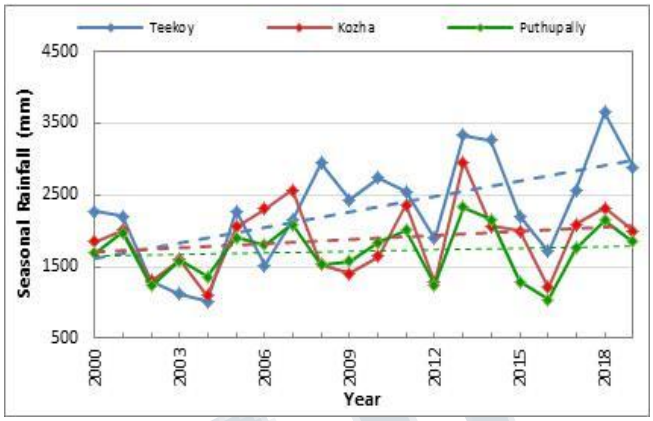
In order to analyse the seasonal rainfall, the IMD classification is used, which divides the year into four seasons, namely, South-West monsoon season (June to September), North-East monsoon season (October to December), Winter season (January to February) and Pre-monsoon season (March to May). The rainfall variation for the stations during these seasons is illustrated in Fig. 4 (a) to (d). The average seasonal rainfall of these stations is given in Table II.

Spatial Variation

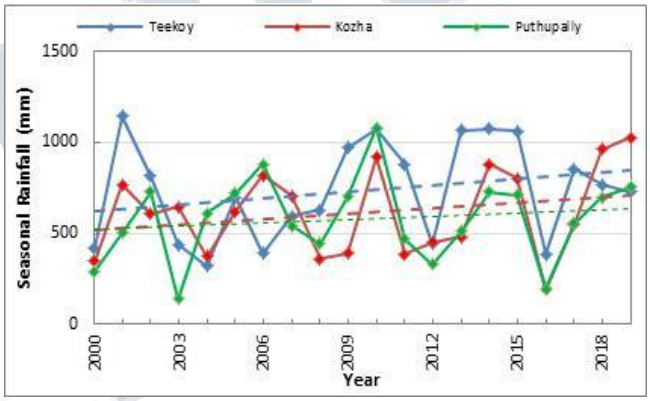
From Fig. 4 and Table II, it can be seen that during both the monsoon seasons, the average rainfall at Teekoy is the highest and lowest is at RRII, Puthupally. This indicates the effect of terrain in the rainfall variability.

Temporal Variation

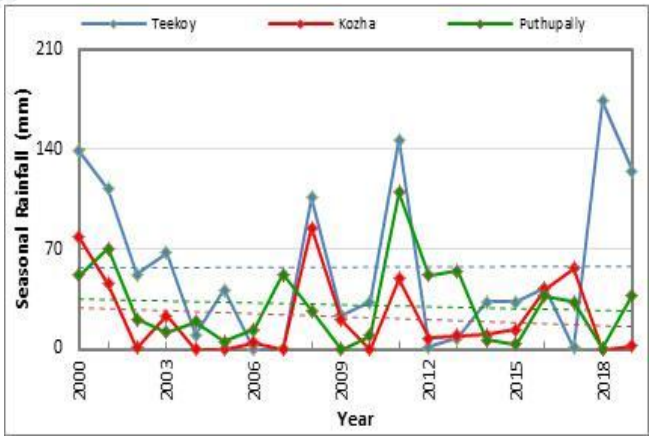
SW and NE Monsoons show increasing trends in all the three stations. Pre-monsoon and Winter rainfalls are increasing at Teekoy but decreasing at Kozha and RRII, Puthupally. This reduction in rainfall in midland and lowland which constitutes 90% of the basin area and has a denser population than highland is a matter of severe concern in terms of availability of water for drinking and irrigation purposes during the dry months.



(a)



(b)



(c)

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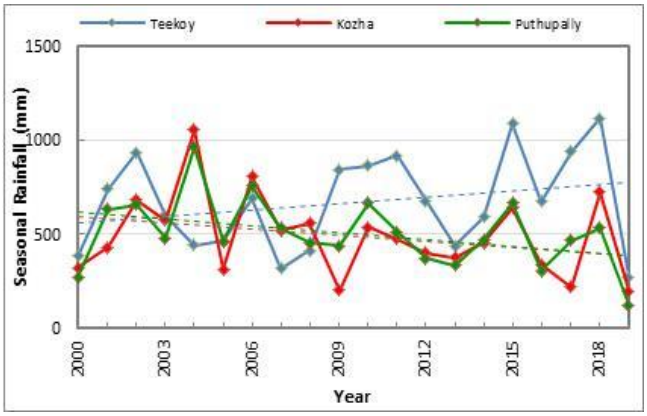

(d)

Fig. 4 Seasonal rainfall variation (a) South-West monsoon (b) North-East monsoon (c) Winter and (d) Pre-monsoon

Table II Average seasonal rainfall

Station	Seasonal rainfall (in mm)			
	SW Monsoon	NE Monsoon	Winter	Pre-Monsoon
Teekoy	2301	739	58	672
Kozha	1882	616	23	492
RRII	1720	581	31	506

C. Monthly Rainfall

The average monthly rainfall variation of these stations for twenty years is studied and is plotted in Fig. 5. It is seen that all the stations exhibit the similar variation pattern. These plots have a rising limb from January and attain their peaks in the month of June and then fall. A small increase is noticed in the month of October due to the NE monsoon. Thus, the maximum rainfall is received during the month of June and the least in January. The plots of rainfall at Kozha and RRII, Puthupally are close to each other, whereas Teekoy is clearly above the others.

D. Basin Average

The point rainfalls obtained from the three rain gauge stations at three different terrains is used to study the annual, seasonal and monthly rainfall pattern of the Meenachil basin, taken as a whole. The average annual and average seasonal rainfall of the basin is illustrated in Fig. 6.

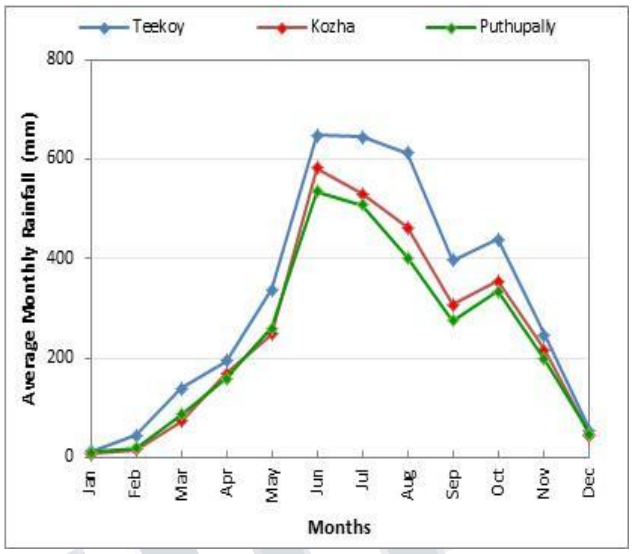

Fig. 5 Average monthly rainfall variation

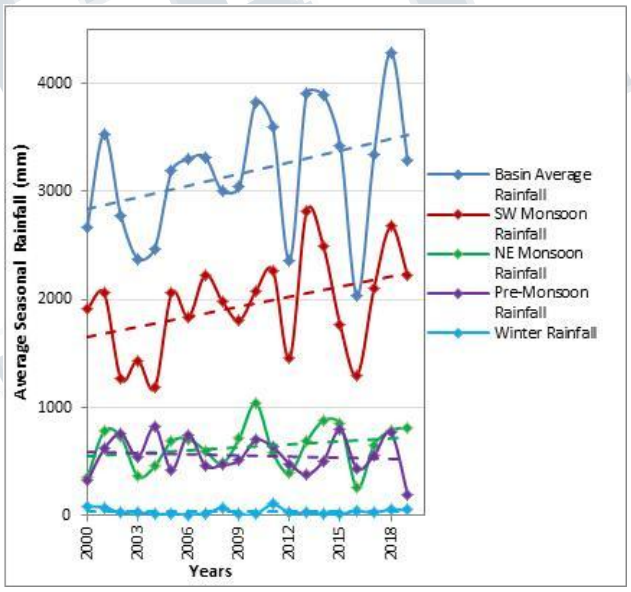

Fig. 6 Average seasonal rainfall variation

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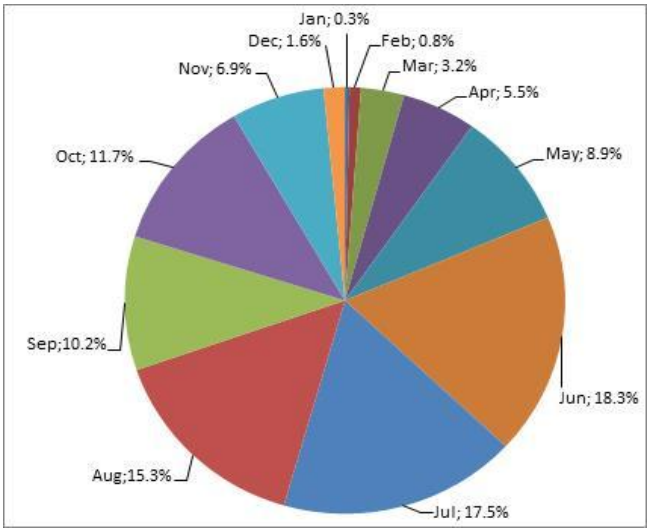

Fig. 7 Percentage monthly share of basin rainfall

Annual Rainfall

Average rainfall of the basin is computed using Theisson Polygon method where area of the polygon is obtained using QGIS software and is calculated as 3183 mm. Annual rainfall time series shows an increasing trend in the basin. It is observed that the peak values are increasing and the trough values are decreasing. This is a clear indication of the possibility of increasing floods and droughts.

Seasonal Rainfall

The percentage monthly spread of rainfall for the period of study is shown using a pie chart in Fig. 7. The seasonal average rainfall contributions are computed as Pre-monsoon – 556.0 mm (17.5%), SW monsoon – 1948.3 mm (61.2%), NE monsoon – 640.8 mm (20.1%) and Winter rainfall – 37.4 mm (1.2%). The SW and NE monsoon rainfalls clearly have an increasing trend but pre-monsoon and winter rains show a decreasing trend.

Monthly Rainfall

It is observed that 51% of the total rainfall is received during three months of the year, i.e., June, July and August. The five dry months, December to April receive only 11.4%.

V. CONCLUSION

The spatial and temporal variations of the rainfall in Meenachil basin is analysed in this paper for a 20-year period from 2000 to 2019. The data from three representative stations from highland, midland and lowland, namely, Teekoy, Kozha and RRII, Puthupally have been used. Trend line of rainfall variation shows that the annual rainfall is increasing with time. This increase is predominant in the highland. QGIS software is used to compute the average annual rainfall for this basin during the period of study. The increasing peak values and decreasing troughs values in annual rainfall time series of the basin indicate the possibility of more floods and droughts.

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