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Rainfall distribution analysis in Kurunegala District, Sri Lanka

M.M.A.P. Manike[1], G.R. Krishnananthy[2*] and M. Rajendran[1]
[1]Department of Agricultural Engineering, Faculty of Agriculture, Eastern University, Sri Lanka
[2]Department of Agricultural Chemistry, Faculty of Agriculture, Eastern University, Sri Lanka
Krishnananthy2028@gmail.com

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Abstract

Studying the spatiotemporal patterns of rainfall has become vital in effectively managing water resources for long-term prosperity. This study was conducted with the objective of investigating the variations in rainfall distribution within the Kurunegala district. To accomplish this, historical rainfall data from four gauging stations were subjected to comprehensive mathematical and statistical analyses. Additionally, the research delved into assessing rainfall trends, rainfall exceedance and the examination of meteorological drought conditions. Rainfall distribution within the district exhibits significant spatio-temporal fluctuations. Bathalagoda stands out with the highest annual mean rainfall, measuring 1843mm. In comparison, Wariyapola, Mediyawa, and Siyambalagamuwa report corresponding figures of 1629mm, 1315mm, and 1222mm, respectively. However, it's worth noting that rainfall is concentrated primarily within specific months of the year. When considering a 50% probability of annual rainfall exceeding a certain threshold, Bathalagoda records 1825mm, while Wariyapola, Mediyawa, and Siyambalagamuwa show figures of 1662mm, 1284mm, and 1226mm, respectively. Interestingly, there is a decreasing trend in annual rainfall for Mediyawa, Wariyapola, and Siyambalagamuwa, while Bathalagoda exhibits an increasing trend. The Southwest monsoonal (SWM) and 2nd inter-monsoonal (IM2) rainfall patterns are displaying a consistent decline across all measurement stations. Conversely, both Mediyawa and Bathalagoda exhibit a positive trend in rainfall during the 1st inter-monsoonal (IM1) and Northeast monsoonal (NEM) periods. There is a negative trend in Maha seasonal rainfall across all regions except for Bathalagoda, where the trend is positive. Additionally, there is a positive trend in Yala seasonal rainfall observed in Mediyawewa and Bathalogoda. Moreover, recent years have seen the occurrence of severe drought conditions in Wariyapola, Mediyawa, and Siyambalagamuwa. In contrast to other areas, Mediyawa and Siyambalagamuwa experience significant deviations from the long-term average in terms of rainfall. The study area exhibits a recurring pattern in the distribution of rainfall over time. Nevertheless, the quantity of rainfall received in recent years has been lower compared to the preceding decade across all regions except Bathalagoda. Therefore, making proper management decisions that consider rainfall distribution patterns is crucial for the effective governance of water resources and ensuring the sustainability of agricultural production.

Keywords: Spatio-temporal variations, rainfall distribution, climate change, meteorological drought, water resource management.

Introduction

The erratic distribution of rainfall due to climate change greatly impacts the agriculture sector, especially in developing countries, as it directly depends on rainfall distribution. Agriculture has always been the backbone of Sri Lanka's rural population and paddy cultivation is the most common type of agriculture, practiced by about 1.8 million farming families across the island. However, recent climate change has had a significant impact on agriculture sector. In different regions of the nation, there has been a notable occurrence of severe weather events, including floods and droughts, over the past few decades. These have been attributed to irregular rainfall patterns and limitations on water resources, leading to crop failures and the abandonment of farming seasons in numerous areas across the country. Kurunegala is one of the major agricultural districts, with a wide range of crop cultivation. Managing the water resources while ensuring the livelihoods of farmers through sustainable food production has become a big challenge in this district. Thorough analysis of past rainfall pattern is essential in understanding how climate change influences water resources and severe weather events. Additionally, it is crucial to explore the changing patterns of meteorological factors over different locations and time periods.

This detailed analysis is vital for efficient water resource management, sustainable development, and reducing the effects of severe weather events, all while ensuring originality and avoiding plagiarism. Further, quantifying hydrological responses to climate change has become extremely important for proper water resources management[1]. In the above context, the present study aimed to analyze the changes in rainfall distribution in Kurunegala district.

Materials and Methods

Study area: Kurunegala is one of the major agricultural districts located in the North-Western province of Sri Lanka. This district falls partially in the dry zone and partially in the intermediate zone. In the present study, rainfall datafor the period from 1961-2017 were collected from Wariyapola, Mediyawa, and Siyambalagamuwa regions and from 1976-2017 from Bathalagoda. Figure 1 shows the location of the study area and data collection points.

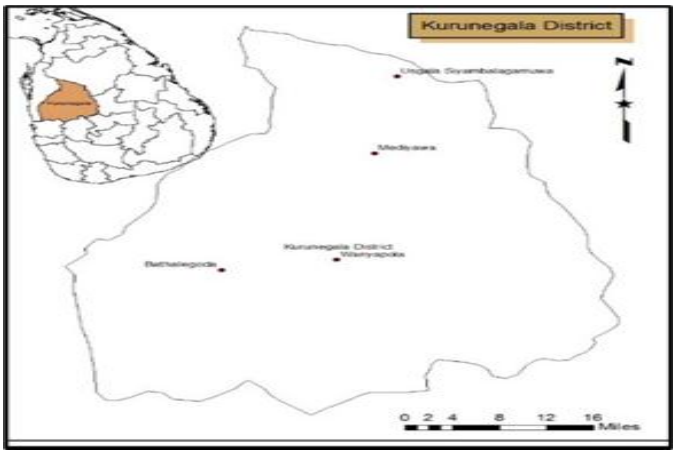

Figure-1: The specific geographical position of the research area and the gauging stations.

Preparation and analysis of rainfall data: Rainfall data from four monitoring stations within Kurunegala district were subjected to a comprehensive assessment, including checks for missing data, outliers, data homogeneity, and adherence to a normal distribution. To address missing values, the normal ratio method was employed for estimation. The homogeneity test, crucial for identifying data variations, was conducted as part of the analysis. The findings presented in Table-1 illustrate the outcomes of two homogeneity assessments. Based on these results, it is reasonable to infer that the datasets obtained from the four stations exhibit homogeneity.

Table-1: Test for homogeneity in Rainfall Data.

Region	Pettitt's test	Buishand's test
Wariyapola	0.093	0.111
Mediyawa	0.388	0.299
Siyambalagamuwa	0.188	0.110
Bathalagoda	0.640	0.709

H0: Data are homogeneous; Ha: There is a date at which there is a change in the data. If the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.

Typically, climate datasets conform to a normal distribution pattern. Nevertheless, it is imperative to assess the normality of the datasets prior to conducting any analysis. Table-2 displays the outcomes of two normality tests. Given that the p-values exceed the threshold value of α (0.05), it is reasonable to conclude that the datasets exhibit a normal distribution.

Table-2: Normality test of rainfall data.

Region	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Wariyapola	.076	43	.200*	.980	43	.642
Mediyawa	.097	43	.200*	.964	43	.201
Siyambala gamuwa	.091	43	.200*	.989	43	.945
Bathalagoda	.087	43	.200*	.972	43	.375

a. Lilliefors Significance Correction; *. This is a lower bound of the true significance.

Analysis of rainfall time series data: Historical rainfall data were subjected to mathematical and statistical analyses. The calculations for arithmetic mean, minimum, maximum, and standard deviation (SD) were performed utilizing XLSTAT software.

Analysis of rainfall distribution patterns: PCI (Precipitation Concentration Index) of Oliver in 1980, further developed by De-Lius et al. has equally been expressed as an indicator of rainfall concentration for annual and seasonal scales (wet and dry seasons) 2,3. In this study, rainfall distribution in different regions inthe study area was analyzed based on PCI values, estimated using the below equation.

$$PCI_{anual} = \frac{\sum_{i=1}^{12} P_i^2}{(\sum_{i=1}^{12} P_i)^2} \times 100$$

P_i rain fall of the i^th month

A PCI value below 10 signifies a uniform distribution of monthly rainfall, suggesting that the rainfall is relatively evenly spread across the months. Conversely, higher PCI values indicate that the rainfall is concentrated within one or a few months in a given year.

Estimation of Expected Rainfall Depth (Xp) for a Given Probability: Estimation of rainfall depths for selected probabilities is required for many practical applications, including designing hydraulic structures, assessing the risk of failures, project designing, and flood management and forecasting. In this study, data sets were tested for goodness of fit. Based on the coefficient of determination (R2) of the fitted line and statistical tests, some data sets were transformed for accurate estimation of the probability of extreme rainfalls using the Weibull method.

Evaluation of the coherent trend of annual and seasonal rainfall pattern: Trend analysis is a crucial tool for understanding patterns within a series of observations, providing insights into deviations from the trend and the nature of that trend4. In this study, the direction of the trend in annual, monthly, and seasonal rainfalls was determined utilizing the non-parametric Mann–Kendall test. Additionally, the magnitude of the trend was assessed through Sen's method.

Analysis of meteorological droughts: Drought indices are widely employed for detecting, monitoring, and evaluating drought occurrences. In this research, meteorological drought was examined through the utilization of the Standardized Precipitation Index (SPI) using the Meteorological Drought Monitoring (MDM) software.

Assessment of Contemporary Shifts in Rainfall Distribution: Recent alterations in rainfall distribution were evaluated by analyzing the deviation of rainfall from the average during the specified base period. Historical rainfall data sets were grouped into four; 1991-2000, 2001-2010, and 2011-2017 for comparison.

Results and Discussion

Descriptive analysis of rainfall data: Bathalagoda shows the highest long term annual meanrainfall of 1843mm whereas the annual mean rainfall of 1629mm, 1315mmand 1222mm were observed at Wariyapola, Mediyawa and Siyambalagamuwa, respectively (Table-3). According to the statistical analysis, the mean annual rainfall of both Wariyapola and Bathalagoda shows significant variation from the mean annual rainfall of Mediyawa and Siyambalagamuwa at 5% significance level. However, the variation is not significant between Bathalagoda and Wariyapola, and between Mediyawa and Siyambalagamuwa.

Moreover, annual rainfall exhibits significant deviations from the long-term mean in all the regions, as illustrated in Figure-2 Rainfall recorded in 2017 was far below to the long-term average. Itwas also noted that rainfall peaks occurred in different years in different regions in this district. This observation highlights notable spatial and temporal variations in the distribution of rainfall within the study area.

Rainfall in Maha season ranges from 80mm – 1625mm in this district. Bathalagodaregion shows the highest mean rainfall of 1064mm in Maha season. Wariyapola receives the second highest of 941mm. Mediyawa and Siyambalagamuwa receive nearly same amount of rainfall during Maha season (Table-4). The amount of rainfall received each year in Yala season fluctuates highly, ranging from 107mm – 1311mm. The highest mean rainfall of 774mm was recorded at Bathalagoda in Yala season, while the lowest mean rainfall of 391mm was observed at Siyambalagamuwa. Wariyapola shows fairly good rainfall in Yala season.

Table-3: Statistical overview of annual Rainfall data from four regions in Kurunegala District.

Gauging Stations	Minimum.	Maximum.	Mean	Standard Deviation
Wariyapola	371.9	2401.8	1629.1	331.8
Mediyawa	564.2	2586.7	1315.0	405.1
Siyambalagamuwa	300.9	2078.6	1222.1	322.9
Bathalagoda	1259.9	2634.6	1842.6	319.7

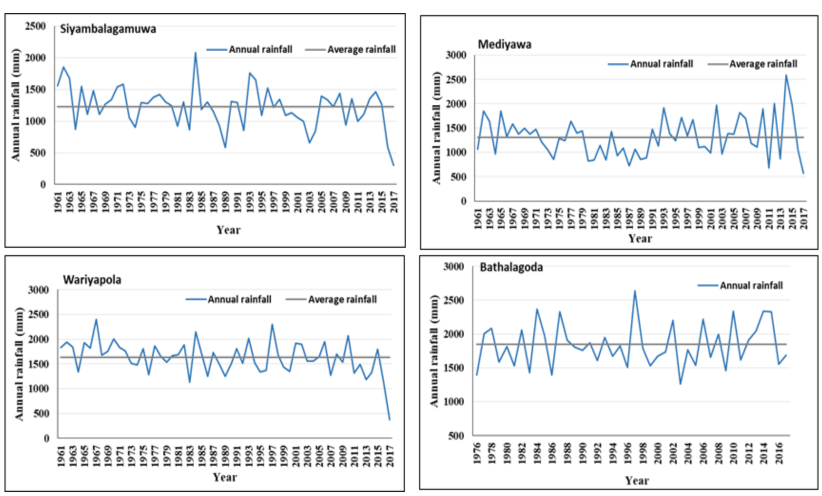

Figure-2: Variability in Annual Rainfall Distribution across Different Regions in Kurunegala District.

Compared to other regions, Bathalagoda receives higher amount of rainfall during all monsoonal seasons (Table-5). In this district, SWM and IM2 rainfalls are more effective. However, monsoonal failure is observed during inter-monsoonal period, particularly during IM2.

Rainfall distribution based on PCI: In general, rainfall distribution in the study area shows moderate or high concentration, concentrated in certain months in a year (Table-6). Compared to other regions, nearly 74% of the years showed moderate concentration at Bathalagoda, while it was 54% at Wariyapola. Nearly 44% of years at Mediyawa showed high concentration, while about 39% of the years showed high concentration at Siyambalagamuwa. At Siyambalagamuwa, 30% of the years showed very high concentration. The corresponding value for Mediyawa is 18%.

Estimation of Expected Rainfall Depth (Xp) for a Given Probability Level: Bathalagoda experiences more extreme rainfall levels at all probability thresholds. For instance, the annual rainfall exceeding a 50% probability level is recorded at 1825 mm, as depicted in Figure-3. However, the corresponding figures for Wariyapola, Mediyawa and Siyambalagamuwa are 1662 mm, 1284 mm and 1226 mm, respectively. Further, rainfall depth at 80% probability level is 1575mm at Bathalagoda and it is 1380 mm, 974 mm, 956 mm at Wariyapola, Mediyawa, and Siyambalagamu, respectively.

Table-4: Descriptive statistics of *Maha* and *Yala* seasonal rainfall collected from four regions in Kurunegala district.

	Maha season				Yala season			
Station	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Wariyapola	79.5	1583.9	940.8	251.5	292.4	1136.4	688.3	197.6
Mediyawa	142.8	1619.3	826.6	321.0	106.8	967.4	488.4	164.3
Siyambalagamuwa	100.2	1466.9	831.5	298.7	112.8	788.0	390.5	142.3
Bathalagoda	453.0	1625.3	1063.7	256.3	441.6	1310.8	773.5	196.8

Table-5: Descriptive statistics of monsoonal rainfalls collected from four regions in Kurunegala district.

Monsoon	Station	Min.	Max.	Mean	SD
IM1	Wariyapola	32	700	337	139
	Mediyawa	0	614	283	135
	Siyambalagamuwa	20	609	232	125
	Bathalagoda	93	674	346	138
SWM	Wariyapola	67	822	465	145
	Mediyawa	21	722	270	134
	Siyambalagamuwa	9	578	228	118
	Bathalagoda	155	1013	545	176
IM2	Wariyapola	0	1062	568	209
	Mediyawa	0	1081	502	241
	Siyambalagamuwa	0	972	480	204
	Bathalagoda	268	1212	634	220
NEM	Wariyapola	26	791	259	145
	Mediyawa	23	611	260	132
	Siyambalagamuwa	20	694	283	154
	Bathalagoda	81	795	312	166

Table-6: Rainfall Distribution Analysis Using PCI in Various Regions of Kurunegala.

Index	Description	Number of years			
		Wariyapola (1961-2017)	Mediyawa (1961-2017)	Siyambalagamuwa (1961-2017)	Bathalagoda (1976-2017)
<10	Low concentration (almost uniform rainfall)	2	0	0	1
11-15	Moderate concentration	31	22	18	31
16-20	High concentration	21	25	22	9
≥20	Very high concentration	3	10	17	1

Trend analysis: Trend of annual rainfall: Figure-4 illustrates the trend in recorded rainfall across distinct regions in Kurunegala district. Consequently, it is observed that annual rainfall exhibits a declining trend in all regions, except for Bathalagoda.

However, the trendis significant only at Wariyapoala and Siyambalagamuwa at 95% confidence level (Table-7).

Trend of monthly rainfall: Table-8 provides an overview of the monthly rainfall trends in various regions within the study area. According to the data, Wariyapola experiences decreasing trends in monthly rainfall for most months, except for January, February, and December. Additionally, there is a increasing trend observed in December, although it is not statistically significant at a 95% confidence level. Positive trend of rainfall was observed in January, March, April and November at Mediyawa. However, rainfall in July shows significant decreasing trend. Trend was negative almost in all months and significant in the months of July and December at Siyambalagamuwa. At Bathalagoda, a decreasing trend was observed in June, July, September, October and November. The trend was significant in November. However, the trend was positive in other months but not significant at 95% confidence level.

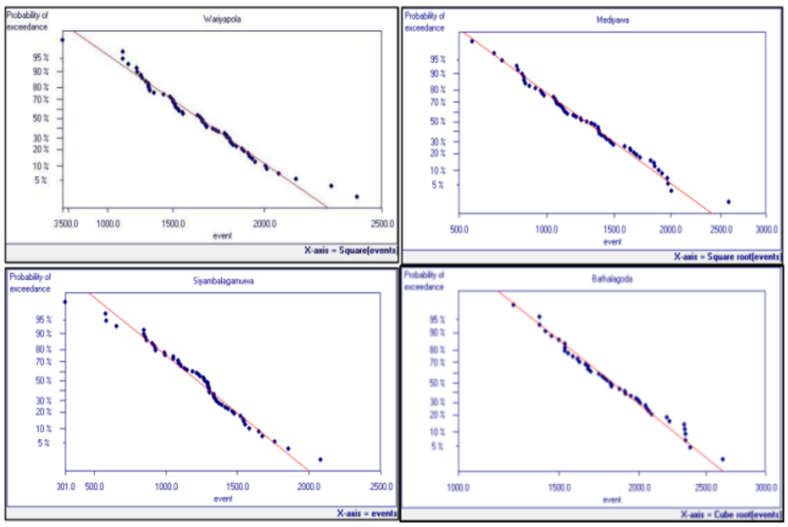

Figure-3: Probability Analysis of Extreme Rainfall Depths across Various Regions in Kurunegala District.

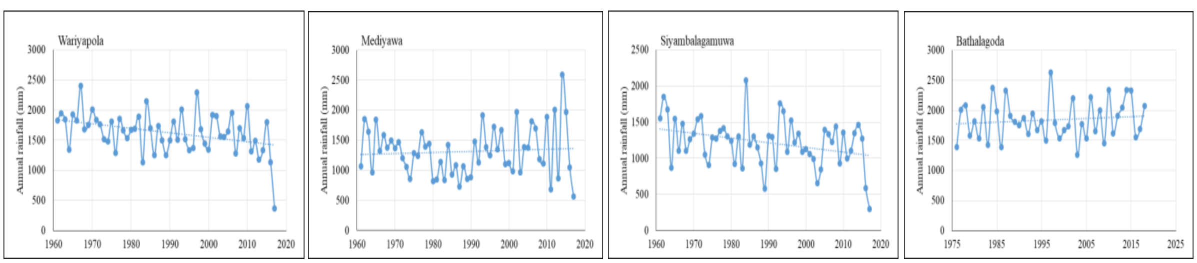

Figure-4: Trend Analysis of Annual Rainfall Recorded in Various Regions of Kurunegala District.

Table-7: Trend Analysis of Annual Rainfall Recorded in Various Regions of Kurunegala District.

Stations	Sen’s slope	p-value	Sig.
Wariyapola (1961-2017)	-7.352	0.006	*
Mediyawa (1961-2017)	-0.041	1.000	ns
Siyambalagamuwa (1961-2017)	-6.433	0.028	*
Bathalagoda (1976-2017)	2.726	0.532	ns

* Significant at 5% significance level; ns-not significant.

Trend of seasonal rainfall: A decreasing trend was observedin *Maha* season rainfall in all regions except Bathalagoda. A significant negative trend was observed at Siyambalagamuwa (Table-9). Further, a negative trend in *Yala* season rainfall was observed at both Wariyapola and Siyambalagamuwa whilst Mediyawa and Bathalagoda showed a positive trend.

Table-10 shows the trends of monsoonal rainfalls in different regions in the study area. A positive trend of first inter-monsoon (IM1) was observed at both Mediyawa and Bathalagoda while Wariyapola and Siyambalagamuwa showed a negative trend. All regions show a negative trend of southwest monsoonal (SWM) rainfall and it is significant at Wariyapola and Siyambalagamuwa. Further, the second inter-monsoonal (IM2) rainfall shows a decreasing trend in all regions and the trend is significant at Bathalagoda. Trend of north-east monsoonal (NEM) rainfall is negative at Wariyapola and Siyambalagamuwa. However, Bathalagoda shows a significant positive trend of NEM rainfall.

Trend of number of rainy days; In the present study, a day with rainfall more than 2.5 mm is considered as rainy day. Figure-5 shows the trend of rainy days in different regions in Kurunegala district. Number of rainy days show a decreasing trend in all regions except Bathalagoda.

Table-8: Statistical Parameters of Recorded Monthly Rainfall for Trend Analysis at Various Locations in Kurunegala District.

Month	Wariyapola		Mediyawa		Siyambalagamuwa		Bathalagoda	
	Sen's slope	p-value	Sen's slope	p-value	Sen's slope	p-value	Sen's slope	p-value
January	0.000	0.683	0.319	0.392	-0.383	0.378	0.475	0.470
February	0.000	0.739	0.000	0.641	-0.070	0.479	0.768	0.107
March	-0.004	0.995	0.242	0.549	-0.234	0.389	0.200	0.819
April	-0.649	0.453	0.285	0.757	-0.362	0.635	0.857	0.603
May	-1.573	0.082	-0.353	0.577	-0.242	0.591	0.925	0.618
June	-0.451	0.250	-0.029	0.777	0.000	0.396	-0.213	0.739
July	-0.531	0.247	-0.372	0.026	-0.228	0.046	-0.833	0.103
August	-0.126	0.577	0.000	0.617	0.000	0.805	0.500	0.252
September	-0.883	0.123	-0.240	0.224	-0.754	0.084	-0.038	0.983
October	-1.621	0.162	-1.018	0.474	-1.39	0.302	-0.994	0.479
November	-1.110	0.302	0.649	0.470	-1.059	0.409	-4.117	0.009
December	0.139	0.826	-0.311	0.695	-1.747	0.015	2.103	0.082

The trend is significant at p-value less than 0.05 at a 5% significance level.

Table-9: Trend analysis of rainfall data for *Maha* and *Yala* seasons collected from four regions in Kurunagela district.

	Maha season			*Yala season*		
Station	Sen's slope	p-value	Sig.	Sen's slope	p-value	Sig.
Wariyapola	-2.8074	0.1665	ns	-3.1601	0.0482	*
Mediyawa	-0.5548	0.8526	ns	0.2184	0.8959	ns
Siyambalagamuwa	-5.4372	0.0151	*	-0.9912	0.4127	ns
Bathalagoda	0.6611	0.8464	ns	2.3167	0.4127	ns

Trend is significant at p-value less than 0.05 at 5% significance level.

Table-10: Trend analysis of monsoonal rainfalls in different regions in Kurunegala district.

Region	IM1		SWM		IM2		NEM	
	Sen's slope	p value	Sen's slope	p value	Sen's slope	p value	Sen's slope	p value
Wariyapola	-0.775	0.470	-3.464	0.001	-2.889	0.068	-0.198	0.885
Mediyawa	1.260	0.268	-1.812	0.101	-0.821	0.665	0.352	0.746
Siyambalagamuwa	-0.123	0.907	-2.150	0.032	-2.341	0.173	-2.464	0.027
Bathalagoda	1.561	0.388	-0.594	0.714	-5.973	0.041	6.2412	0.001

Trend is significant at p-value less than 0.05 at 5% significance level.

Assessment of Drought Using the Standardized Precipitation Index (SPI): In accordance with Cacciamani et al.[5], positive SPI values signify wet conditions characterized by above-median precipitation, whereas negative SPI values indicate dry conditions marked by below-median precipitation. The severe dry condition was observed in 2017 in all regions except Bathalagoda (Table-11). There were only two very wet events in 1967 and 1997 at Wariyapola. Further, moderate wet events were observed in 1970, 1984, 1993, and 2010. Moderate dry events were observed in 1983, 1986, 1989, 2013, and 2016.

Other years were showed a normal observation at Wariyapoala. At Mediyawa, an extreme wet event was observed in 2014 whereas very wet events were observed in 2002 and 2005. Moderate wet conditions were observed in 1962, 1965, 1993, 1996, 2006, and 2010. The years 1974, 1980, 1981, 1983, 1989, 1990 were moderately dry while 1987 and 2011 were very dry. An extreme wet event was observed in 1984 at Siyambalagamuwa. The years 1962, 1972 were very wet whereas 1963, 1993, and 1994 were moderately wet.

Moderately dry events were observed in 1964, 1983, 1992, and 2004. Severe dry events were observed in 1989 and 2003. The years 2016 and 2017 were extremely dry. At Bathalagoda, very wet events were in 1984, 2010, and 2014 while the years 1987, 2006, and 2015 were moderately wet. The moderate dry condition was observed in 1983, 1996, and 2009. The years 1976 and 1986 were severe dry while 2003 was extremely dry. In general, the distribution of rainfall in the study area exhibits a lack of uniformity, with significant variations occurring from one year to the next and from one location to another.

Analysis of Contemporary Shifts in Rainfall Distribution: To assess the recent changes in rainfall distribution within the study area, the deviation of annual rainfall from the average rainfall during the base period was examined. Figure-6 illustrates a notable fluctuation in annual rainfall across all regions. Mediyawa and Siyambalagamuwa exhibit substantial fluctuations from the long-term average, with deviations reaching nearly 1000 mm per year in certain years. In contrast, Wariyapola and Bathalagoda experience a relatively minor departure from the average during the base period when compared to the other regions.

Coefficient of variation (CV) in annual rainfall highly increased in the recent years in all regions except Bathalagoda. Highest CV of 65.6% observed at Siyambalagamuwa whereas Bathalagoda showed lowest CV of 16.8% during 2011-2017 (Table-12). Variation in rainfall distribution has been increasing at Mediyawa and Siyambalagamuwa since past three decades. Compared to other regions, variation in annual rainfall distribution is low at Bathalagoda.

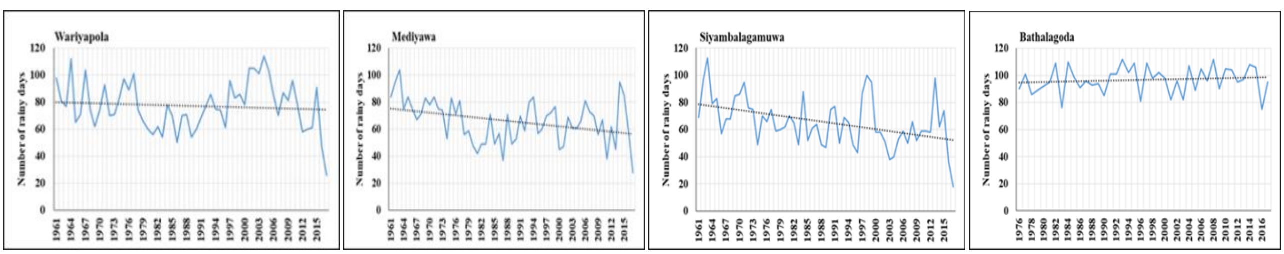

Figure-5: Analysis of the Trend in the Number of Rainy Days across Various Locations in Kurunegala.

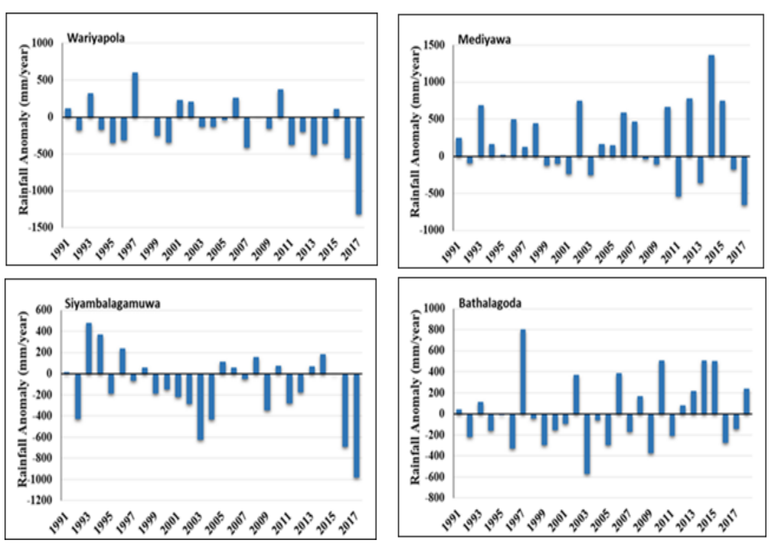

Figure-6: Departure of annual rainfall with respect to base period (1961-1990). Base period for Bathalagoda is from 1976-1990.

Table-11: Assessment of Annual Drought Conditions Using SPI in Various Regions of Kurunegala.

Year	Wariyapola		Mediyawa		Siyambalagamuwa		Bathalagoda	
	SPI	Condition	SPI	Condition	SPI	Condition	SPI	Condition
1961	0.59	Normal	-0.57	Normal	0.96	Normal	-	-
1962	0.86	Normal	1.29	Moderate wet	1.64	Very wet	-	-
1963	0.62	Normal	0.86	Normal	1.24	Moderate wet	-	-
1964	-0.73	Normal	-0.87	Normal	-1.01	Moderate dry	-	-
1965	0.82	Normal	1.28	Moderate wet	0.94	Normal	-	-
1966	0.57	Normal	0.11	Normal	-0.24	Normal	-	-
1967	1.86	Very wet	0.74	Normal	0.78	Normal	-	-
1968	0.20	Normal	0.25	Normal	-0.25	Normal	-	-
1969	0.39	Normal	0.53	Normal	0.22	Normal	-	-
1970	1.00	Moderate wet	0.24	Normal	0.42	Normal	-	-
1971	0.59	Normal	0.48	Normal	0.92	Normal	-	-
1972	0.43	Normal	-0.18	Normal	1.03	Moderate wet	-	-
1973	-0.22	Normal	-0.58	Normal	-0.4	Normal	-	-
1974	-0.32	Normal	-1.21	Moderate dry	-0.89	Normal	-	-
1975	0.54	Normal	0.02	Normal	0.29	Normal	-	-
1976	-0.89	Normal	-0.08	Normal	0.24	Normal	-1.49	Severe dry
1977	0.66	Normal	0.85	Normal	0.51	Normal	0.58	Normal
1978	0.16	Normal	0.30	Normal	0.63	Normal	0.81	Normal
1979	-0.17	Normal	0.40	Normal	0.31	Normal	-0.8	Normal
1980	0.18	Normal	-1.34	Moderate dry	0.14	Normal	-0.01	Normal
1981	0.24	Normal	-1.26	Moderate dry	-0.83	Normal	-0.97	Normal
1982	0.73	Normal	-0.35	Normal	0.33	Normal	0.73	Normal
1983	-1.39	Moderate dry	-1.26	Moderate dry	-1.05	Moderate dry	-1.36	Moderate dry
1984	1.32	Moderate wet	0.37	Normal	2.11	Extreme wet	1.62	Very wet
1985	0.27	Normal	-0.98	Normal	-0.01	Normal	0.51	Normal
1986	-1.01	Moderate dry	-0.51	Normal	0.33	Normal	-1.49	Severe dry
1987	0.36	Normal	-1.68	Severe dry	-0.11	Normal	1.49	Moderate wet
1988	-0.27	Normal	-0.55	Normal	-0.81	Normal	0.28	Normal
1989	-1.01	Moderate dry	-1.22	Moderate dry	-2.18	Extreme dry	-0.03	Normal
1990	-0.27	Normal	-1.11	Moderate dry	0.34	Normal	-0.2	Normal
1991	0.54	Normal	0.48	Normal	0.29	Normal	0.16	Normal
1992	-0.24	Normal	-0.39	Normal	-1.08	Moderate dry	-0.71	Normal
1993	1.02	Moderate wet	1.42	Moderate wet	1.44	Moderate wet	0.4	Normal
1994	-0.21	Normal	0.27	Normal	1.19	Moderate wet	-0.49	Normal
1995	-0.74	Normal	-0.07	Normal	-0.29	Normal	0	Normal
1996	-0.63	Normal	1.03	Moderate wet	0.88	Normal	-1.08	Moderate dry
1997	1.64	Very wet	0.18	Normal	0.08	Normal	2.3	Extreme wet
1998	0.21	Normal	0.92	Normal	0.42	Normal	-0.1	Normal
1999	-0.44	Normal	-0.46	Normal	-0.29	Normal	-0.97	Normal
2000	-0.72	Normal	-0.41	Normal	-0.17	Normal	-0.48	Normal
2001	0.81	Normal	-0.8	Normal	-0.39	Normal	-0.26	Normal
2002	0.76	Normal	1.53	Very wet	-0.59	Normal	1.14	Moderate wet
2003	-0.1	Normal	-0.85	Normal	-1.85	Severe dry	-2.02	Extreme dry
2004	-0.11	Normal	0.28	Normal	-1.09	Moderate dry	-0.16	Normal

2005	0.13	Normal	0.25	Normal	0.56	Normal	-0.96	Normal
2006	0.88	Normal	1.23	Moderate wet	0.41	Normal	1.19	Moderate wet
2007	-0.93	Normal	0.97	Normal	0.12	Normal	-0.53	Normal
2008	0.26	Normal	-0.23	Normal	0.67	Normal	0.56	Normal
2009	-0.17	Normal	-0.43	Normal	-0.79	Normal	-1.25	Moderate dry
2010	1.14	Moderate wet	1.37	Moderate wet	0.45	Normal	1.53	Very wet
2011	-0.81	Normal	-1.86	Severe dry	-0.58	Normal	-0.67	Normal
2012	-0.3	Normal	1.59	Very wet	-0.25	Normal	0.29	Normal
2013	-1.24	Moderate dry	-1.19	Moderate dry	0.44	Normal	0.70	Normal
2014	-0.76	Normal	2.6	Extreme wet	0.74	Normal	1.52	Very wet
2015	0.51	Normal	1.53	Very wet	0.23	Normal	1.50	Moderate wet
2016	-1.38	Moderate dry	-0.63	Normal	-2.16	Extreme dry	-0.89	Normal
2017	-5.03	Extreme dry	-2.34	Extreme dry	-3.83	Extreme dry	-0.43	Normal

Table-12: Descriptive statistics of rainfall data analysed for different time periods.

Period	Wariyapola			Mediyawa			Siyambalagamuwa			Bathalagoda		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Base period	1689	282	16.7	1224	317	25.9	1280	314	24.5	1825	323	17.7
1991-2000	1633	320	19.6	1411	282	20.0	1294	281	21.7	1805	325	18.0
2001-2010	1713	244	14.3	1439	380	26.4	1124	265	23.6	1818	360	19.8
2011-2017	1232	439	35.6	1388	789	56.8	818	536	65.6	1945	326	16.8

Conclusion

Rainfall distribution in Kurunegala shows high spatio-temporal variations. Annual, monthly and seasonal rainfalls show positive and negative trends. Extreme events are experienced in many years over the past three decades. Rainfall distribution shows a cyclic pattern over time. However, the amount of rainfall received in recent years is lower than the immediate past decade in all locations, except for Bathalagoda. Hence, proper management decisions based on distribution patterns of rainfall is vital for the efficient management of water resources while guaranteeing sustainable agricultural production.

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