

# Interannual variability of precipitation in Sri Lanka : A comparative study of observation periods 1881-1980, 1931-1980, 1951-1980

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**सार** — 100 वर्ष की अवधि (1881-1980) में विस्तृत वार्षिक निरपेक्ष वर्षों के आधार पर 1931-1980 और 1951-1980 की प्रेक्षण अवधियों के साथ तुलना में विभिन्न सांख्यिकीय सूचकांकों के द्वारा श्रीलंका के 14 मौसम विज्ञान स्टेशनों की अंतर-वार्षिक वर्षों की परिवर्तनशीलता का विवेचन किया गया है। कालगत और क्षेत्रीय पहलुओं (श्रीलंका के आर्द्र और शुष्क क्षेत्र) के अन्तर्गत संख्या, सूखे की घटनाओं की संख्या, बारंबारता और प्रसंभाव्यता (गणतीय वर्षा माध्य का  $\leq 75\%$ ), सूखा-मुक्त ( $> 75\%$ ) और आर्द्र वर्षों ( $\geq 125\%$ ) का परीक्षण किया गया है। यहां पर शुष्क क्षेत्र के अंतर्गत सभी तीनों प्रेक्षण अवधियों में वर्षों की बहुत अधिक निश्चित अस्थिरता देखी गई है, आर्द्र क्षेत्र में अपेक्षाकृत सूखामुक्त लम्बी अवधियों में सूखे के वर्ष कम हैं और कहीं व यदाकदा पाए जाते हैं। एक मूल्यांकन कुंजी के अनुसार सूखे के वर्ष 1975-1978 असाधारण रूप से उच्च स्तर पर हैं जिसकी तुलना केवल 1908-1911 के वर्षों के साथ की जा सकती है। सबसे अधिक तेज सूखे वाले वर्ष 1974 (शुष्क क्षेत्र में) और 1908/1976 (आर्द्र क्षेत्र में) और आर्द्र वर्ष 1957 (शुष्क क्षेत्र में) और 1963 (आर्द्र क्षेत्र में) हैं।

**ABSTRACT.** On the basis of the annual absolute rainfall totals over a 100-year period (1881-1980) the interannual rainfall variability of 14 meteorological stations in Sri Lanka is being discussed by means of different statistical indices in comparison with the observation periods 1931-1980 and 1951-1980. Number, frequency and probability of occurrence of drought ( $\leq 75\%$  of the arithmetical rainfall mean), drought-free ( $> 75\%$ ) and wet years ( $\geq 125\%$ ) were examined under temporal and regional aspects (wet and dry zone of Sri Lanka). There is a very distinct rainfall variability in all three observation periods within the dry zone; in the wet zone, the drought years within longer drought-free periods are fewer and occur sporadically. According to an evaluation key the drought years 1975-1978 are on an extraordinary high level comparable only with the years 1908-1911. Drought years with a maximum intensity are 1974 (within the dry zone) and 1908/1976 (within the wet zone) and wet years 1957 (in dry zone) and 1963 (in wet zone).

## 1. Introduction

Reports on phenomena like droughts and dry periods or even the absence of monsoonal rainfall in south Asia, which have been occurring more and more frequently in these past years were the reason for undertaking this climatic-statistical survey on the interannual variability of precipitation taking Sri Lanka as an example and using the data compiled over a 100-year observation period (1881-1980) compared to the last 50-year (1931-1980) and 30-year (1951-1980) observation period. In this connection, the objective was also to examine whether dry periods of a similar extent had occurred already in previous times.

## 2. Methodology

The survey is based on 14 official main observation stations (Fig. 1) run by the Department of Meteorology of Sri Lanka, with homogeneous data gathered from 1881 to 1980. The stations are distributed all over the island. Absolute annual precipitation was taken as the basis of this study. Based upon the arithmetical mean of the

100-year period ( $= 100\%$ ), the range between  $\leq 75\%$  &  $\leq 50$  or  $\geq 125\%$  &  $\geq 150\%$  was illustrated with a view to the interannual variability and to document particularly dry as well as exceedingly wet years. The same method, including the data available but based upon the 50-year and 30-year arithmetical mean was applied to observation periods 1931-1980 as well as 1951-1980 and contrasted with the values established for the 100-year period, thus making a relative comparison with each other possible. This offers, moreover, the possibility of verifying the reliability of shorter observation periods, especially with respect to a potential underrating or overrating of allegedly "dry" or "wet" years. At this place it is to be stressed that in the present survey greater emphasis is being placed on the temporal phenomena of long-term observations than on regional aspects. In view of the comparatively broad-meshed distribution of the 14 stations, no particular difference was made in respect to location. Only a separate evaluation for the wet and the dry zone in Sri Lanka seemed reasonable (delimitation according to occurrence of an "actual dry period", taking into account up-to-date values of precipitation;

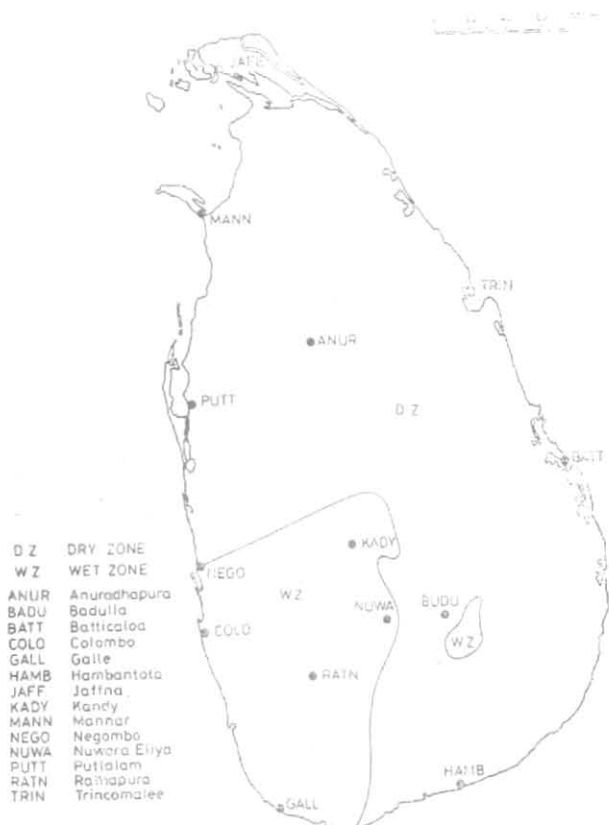


Fig. 1. Location of the meteorological stations in the wet and the dry zones of Sri Lanka

TABLE 1

Absolute and relative number of dry and drought-free years within 3 observation periods

Period	Drought-free years (< 75%)	Dry years (> 75%)
<b>Dry zone</b>		
1881-1980	59 (59%)	25 (25%)
1931-1980	28 (56%)	16 (32%)
1951-1980	18 (60%)	10 (30%)
<b>Wet zone</b>		
1881-1980	80 (80%)	17 (17%)
1931-1980	40 (80%)	10 (20%)
1951-1980	22 (73%)	18 (27%)

TABLE 2

Number and order of rank (evaluation key) of the dry and the wet years within 3 observation periods

	1881-1980	1931-1980	1951-1980
<b>Dry years</b>			
Dry zone	(1) 1974 (7/1)	(1) 1974 (7/1)	(1) 1974 (7/1)
	(2) 1890 (6)	(2) 1950 (7)	(2) 1968 (6/1)
	(3) 1912 (4/1)	(3) 1968 (5/1)	(3) 1980 (5/1)
	1980 (4/1)		
	(4) 1950 (5)	(4) 1980 (4/1)	(4) 1956 (4)
	1968 (5)		
Wet zone	(5) 1889 (3/1)		
	1952 (3/1)		
	(6) 1909 (4)		
	1915 (4)		
	(1) 1908 (4/1)	1976 (3/1)	1976 (3/1)
	(2) 1976 (3/1)		
<b>Wet years</b>			
Dry zone	(1) 1957 (7/5)	(1) 1957 (7/5)	(1) 1957 (7/3)
	(2) 1963 (7/2)	(2) 1963 (6/1)	(2) 1963 (6)
	(3) 1891 (4/3)	(3) 1931 (5)	(3) 1961 (3/1)
	(4) 1913 (4/2)	(4) 1939 (3/1)	1951 (3/1)
		1951 (3/1)	1961 (3/1)
		1965 (3/1)	
Wet zone	(5) 1898 (4/1)		
	1951 (3/2)		
	1902 (5)		
	1931 (5)		
	(6) 1883 (3/1)		
	1884 (3/1)		
	1896 (3/1)		
	1961 (3/1)		
	1923 (4)		
	(1) 1963 (3/3)	(1) 1963 (3/3)	1963 (3/3)
	(2) 1961 (2/2)	(2) 1933 (3/1)	
	1933 (3/1)		
	1925 (4)		

Data basis : Years with at least 4 stations with < 75 and > 125% of the respective annual mean of precipitation.

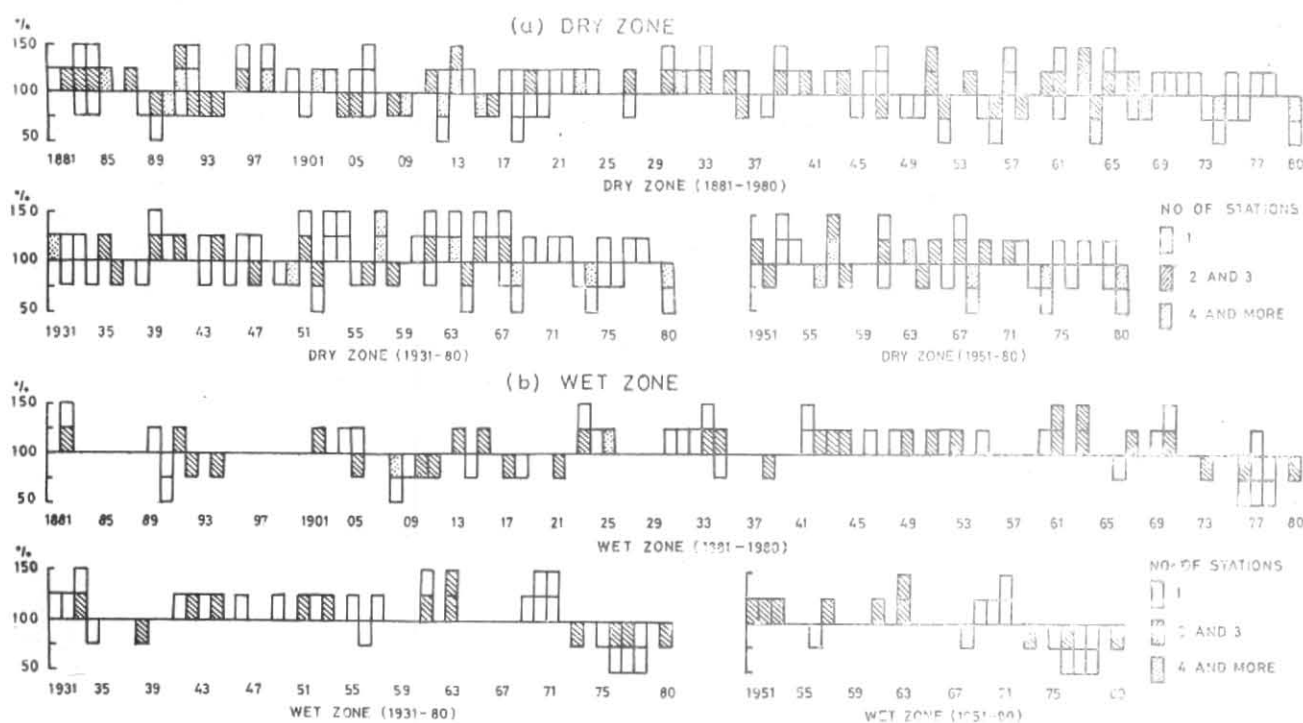
Evaluation key :

Dry years — (x/y) : x = No. of stations with annual precipitation < 75 to > 50%  
y = No. of stations with annual precipitation < 50%

Wet years — (x,y) : x = No. of stations with annual precipitation > 125 to < 150%  
y = No. of stations with annual precipitation > 150%

Domrös 1971, Wikkramatilleke 1963). An approach distinguishing between the wet and the dry zone in Sri Lanka has, in many cases, already proved very useful, especially from an agro-climatical point of view. There are 8 stations in the dry zone and 6 in the wet :

Dry zone	Wet zone
Anuradhapura	Colombo
Badulla	Galle
Batticaloa	Kandy
Hambantota	Negombo (located on the border line defined above)
Jaffna	Nuwara Eliya
Mannar	Ratnapura
Puttalam	
Trincomalee	



Figs. 2 (a & b). Interannual variability of precipitation in the dry zone of Sri Lanka within 3 observation periods 1881-1980, 1931-1980 and 1951-1980 : (a) dry zone and (b) wet zone

previous surveys on precipitation in Sri Lanka (cf. in particular Domrös 1971, 1974, 1978, 1981) have proved the occurrence of droughts which on the island are usually clearly delimited as to time (mostly seasonal) and region. Therefore, arid conditions cannot be found anywhere on the island.

According to the drought index used by the Department of Meteorology of Sri Lanka, drought is to be understood in the following as the  $\leq 75\%$  range, a dry year as a year where the annual values of all stations are exclusively in the  $\leq 75\%$  range. Taking this as the basis for evaluation seasonal dry periods cannot be singled out, if precipitation in the respective year reaches a value of  $>75\%$ . Hence, for this purpose, a further analysis of precipitation data on a monthly or seasonal basis is necessary. In analogy with this, years where the annual values of all stations are  $>75\%$ , are considered to be absolutely drought-free, years with  $\geq 125\%$  are regarded as "wet years". In most cases not all stations could be singled out within one of the defined value ranges, so that in such cases the exact term should be regional dry or regional wet year. The terms dry and wet years in the following text should be considered in this sense.

### 3. Results

The diagrams (Figs. 2 a & b) differentiating between the wet and the dry zone, show that, generally, there is a by far higher interannual variability for the stations in the dry zone with comparatively few years in the  $>75$  to  $<125\%$  range (recorded as drought-free years). Consequently, the proportion of years with values in the  $\leq 75$  and  $\geq 125\%$  range is relatively high.

The less marked variability within the wet zone becomes graphically evident by the comparatively high number (more than 40%) of years recorded as drought-free with values between  $>75$  and  $<125\%$ . Seen from this angle, the conditions are considerably more homogeneous than in the dry zone.

Especially in the dry zone inconsistencies appear in some years, in as much as there are stations simultaneously appearing in the 125-150% as well as in the 75-50% range (Table 1); this means regional occurrence or absence of drought, the reason being climatic conditions varying from region to region, something which is not surprising, in view of the, as compared to the wet zone, much larger area.

A comparison between the wet and the dry zone (Figs. 2 a & b) shows that in the dry zone there is a more or less periodical succession of dry and drought-free years, which applies to any of the observation periods surveyed, while for the stations in the wet zone a sporadic occurrence of dry years within longer drought-free periods is characteristic.

What strikes in the dry zone is a concentration of dry years between 1888 and 1894 and — with several interruptions — between 1904 and 1920. Sequences of several drought-free years can be found between 1895 and 1900 as well as partly interrupted between 1921 and 1944.

In the wet zone, we have a concentration of dry years between 1890 and 1894, 1905 and 1921, 1973 and 1980. Almost entirely drought-free are the years 1881-1889, — 1895-1904, 1922-1972 ( 1939-1965 in sequence ). A

remarkable feature is the identical occurrence of dry years between 1973 and 1980 in all three observation periods. In the 50 and 30-year periods, these years are particularly marked by a concentration as compared to the previous years, because they represent the only concentrated occurrence of drought (immediate succession 1975-1978), interrupted only by the drought-free but not exceedingly wet years 1974 and 1979. If compared to the values established for the 100-year period one finds that a drought period of a similar extent had occurred solely between 1908 and 1911. Latest records dating from the eighties reveal a continuation of exceedingly dry years.

On the whole, the comparison of the percentage of drought and drought-free years for the individual observation periods indicates a distinct drop of drought-free years in the period 1951-1980 (as compared to 1881-1980) by 7% in the wet zone, with dry years having increased by 10% (Table 1). In the dry zone, by contrast, with almost unvaried figures for the drought-free years, drought years have increased by 5% in the period 1951-1980 as compared to 1881-1980.

The different deviations from the arithmetical annual mean (100% value) may be attributed partly to the unique occurrence of just one station, hence to regionally limited phenomena (Figs. 2 a & b). Important in connection with the following considerations, therefore, is an evaluation of annual and regional conditions with respect to intensity and frequency of drought and drought-free years.

The order of rank established (Table 2) includes, for all three observation periods, any year with at least four stations each in the  $\leq 75$  to  $\leq 50\%$  or  $\geq 125$  to  $\geq 150\%$  range. Local phenomena were, therefore, not taken into account. Moreover, drought-free years in the range  $> 75$  and  $< 125\%$  were not considered. Hence, this table represents a listing of exceedingly dry and wet years. The order of rank has been established on the basis of an evaluation key following, the total number of stations in the respective years within the  $\leq 75$  or within the  $\geq 125\%$  range. This listing first reveals remarkable differences between the wet and the dry zone in respect to the number of exceedingly wet and dry years, which clearly indicates a more marked variability of precipitation in the dry zone. Moreover, we find a correspondence of identical wet years in both climatic zones only in two cases (1961 and 1963). As for the dry years, there is no parallel, a fact which may be attributed to the marked regional and seasonal differences of the monsoonal climate. Remarkable feature is that the dry years 1974 and 1980 for the dry zone and 1976 for the wet zone have identical place values in all three observation periods. Moreover, there are higher evaluation figures for 1968 and 1950 in the 50-yr period. As for the 100-year period, a concentration of dry years will be noted between 1889 and 1915 and, same as in the two other periods, between 1968 and 1980. As regards the wet years, there is a distinct increase, 13 in the dry zone and 4 in the wet zone within the 100-year period. For 1957 and 1963 the order of rank is

identical in all three observation periods. What strikes is that, using the present method, there is, in the 100-year period, a relatively even distribution of wet years basically only up to 1913 and between 1951 and 1963 within the dry zone. In analogy with this, considering the 50 and 30-year periods, a concentration of wet years between 1951 and 1965 will be noted. After 1965, there are generally no more years with exceedingly high ( $\geq 125\%$ ) precipitation for more than three stations, either within the dry zone or within the wet zone.

The method applied here to identify the interannual variability of precipitation corroborates that especially dry years are by no means an island-wide phenomena. While in the dry zone seven stations at the most are affected by the years appearing most frequently with  $\leq 75\%$  of the mean annual precipitation (1890, 1950, 1968, 1974 and 1980), in the wet zone only two dry years (1908 and 1976) with a maximum of four stations can be singled out. Exceedingly wet years ( $\geq 125\%$ ) such as 1957 and 1963 appear again with at the most seven stations in the dry zone and such as 1963 with three stations in the wet zone.

#### 4. Conclusion

This paper discussed the interannual variability of precipitation in Sri Lanka on the basis of 14 meteorological stations. It has been shown that there is a by far higher interannual variability for the stations in the dry zone than in the wet zone. In the wet zone, drought years within longer drought-free periods are fewer and occur more sporadically than in the dry zone. In comparison the three observation periods (1881-1980, 1931-1980, 1951-1980) it could be shown that the probability of dry years is increasing during the last observation period (1881-1980: 17%, 1951-1980: 27% in the wet zone and 1881-1980: 25%, 1951-1980: 30% in the dry zone). On the contrary the probability of drought-free years is slightly decreasing in the wet zone (1881-1980: 80%, 1951-1980: 73%) while there is nearly no change in the dry zone.

A weakness of this method using the drought index of the Department of Meteorology of Sri Lanka is that drought or drought-free periods do not necessarily coincide with the calendar year. So, further studies should investigate also the aspects of seasonal drought and drought-free periods.

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