

Comparison of rainfall over Ceylon during the Two 30 Year periods (1911 to 1940) and (1931 to 1960)

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(Received January, 1971)

THE average precipitation maps available up to now in the "Report on the Colombo Observatory" ¹ are for the 30 year period (1911-40), these being 1.) The Annual Average Rainfall 2.) The Southwest Monsoon Average Rainfall 3.) The October-February Average Rainfall. The averages for a new 30 year period (1931-60) were worked out for over 300 rainfall stations and the corresponding average maps prepared for this new period. According to the requirements laid down by the World Meteorological Organization,² the minimum density of rainfall stations over generally flat tropical regions should be one station for approximately 900 sq. km. and for mountainous regions, one station for approximately 250 sq. km. These conditions are more or less satisfied.

It is important to note that in the compilation of the new averages for the 30 year period (1931-60), practically all the averages worked out were for stations where full 30 year rainfall data was available. It is for this reason that the period (1931-60) was chosen. In the case of the earlier averages for (1911-40), these were obtained, at many stations, by working out the average for 25, 20, 15 or 10 year periods, such as (1916-40), (1921-40) etc, depending on the data available, and then correcting the averages to a standard 30 year period, by comparison with neighbouring Reseau Stations³.

1. Report on the Colombo Observatory for 1965 (with Maps and Statistics). Government Publications Bureau, Colombo.
2. Guide to Hydrometeorological Practices (1965). WMO—No. 168. T. P. 82, Sec. 3. 2. 2. 1. 1.
3. RESEAU STATIONS—these are selected rainfall stations with long term periods of record. Originally listed in a publication "Reseau Mondial".

1. ANNUAL AVERAGE RAINFALL MAPS

The annual average rainfall over Ceylon ranges from 36 to 224 inches. A comparison of the two annual average maps for the two periods shows no significant change in the rainfall pattern over the Island, although there are some changes in the positions of the isohyets. These changes will be dealt with later.

(a) *Highest and lowest averages*

According to the old averages (1911-40), Carney Estate (Ratnapura) had the highest annual average 228.75 inches. This average for Carney Estate was obtained by working out the average for a 25 year period (1916-40) and then correcting it to the 30 year period (1911-40). This average seems to be too high. The average for the new 30 year period (1931-60) is only 217.92 inches, which is 10.83 inches less than the old average. 'Double Mass Curve Analysis' was used to a limited extent, to test whether such a variation at Carney was possible and the variation was found to be acceptable. A factor which resulted in a relatively high annual average for the earlier period was the very high rainfall of 319.26 inches recorded at Carney in 1923. The annual average at Hapugastenne Group (Ratnapura) which is about 6 miles southeast of Carney, dropped from 210.95 inches for the earlier period (1911-40) to 201.69 inches for the new period (1931-60). According to the new averages (1931-60), the station with the highest annual rainfall is Kenilworth Estate (Ginigathena), where the average is 224.45 inches, the average for the earlier period being 223.95 inches, which was a corrected value. The average for Padupola, which is close to Kenilworth Estate, increased from 206.61 inches (1911-40) to 214.69 inches (1931-60). Thus according to the figures available, the wettest region in Ceylon is the Ginigathena region and not the area just southeast of Adam's Peak, where Carney is situated. It is, however, very probable that the upper reaches of the Adam's Peak wilderness receive an annual rainfall in excess of 230 inches.

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4. DOUBLE MASS CURVE ANALYSIS—A technique used to ascertain that time trends in rainfall data are due to meteorological causes. LINSLEY, KOHLER and PAULHUS (1949). *Applied Hydrology*—McGraw-Hill, pp. 76-77.

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The rainfall stations with annual averages greater than 200 inches are :

		(1911-40) average	(1931-60) average
1. Kenilworth Estate (Ginigathena)	..	223.95 inches C	.. 224.45 inches
2. Wewoltalawa Div. (Halgolla Group, Yatiyantota)	..	200.51 .. C	.. 220.38 ..
3. Carney Estate (Ratnapura)	..	228.75 .. C	.. 217.92 ..
4. Watawala	..	218.59 ..	.. 214.86 ..
5. Padupola	..	206.61 ..	.. 214.69 ..
6. Norton Bridge	..	216.63 .. C	.. 212.40 ..
7. Maliboda Group (Deraniyagala)	..	205.39 .. C	.. 210.44 ..
8. Ingoya Estate (Kitulgala)	..	208.91 .. C	.. 204.29 ..
9. Hapugastenne Group (Ratnapura)	..	210.95 .. C	.. 201.69 ..
10. Blackwater Estate (Nawalapitiya)	..	203.39 ..	.. 200.51 ..

The letter C alongside the (1911-40) average indicates that the data available for that station was for a period less than 30 years and that the average is a corrected value.

The lowest annual averages for the new 30 year period (1931-60) are Maha Lewaya 36.59 inches and Yala 37.40 inches, both stations being in the southeast of the Island. Maha Lewaya is situated 2 miles to the northeast of Hambantota. Other stations with annual averages less than 40 inches are along the northwestern coastal belt, these being Mannar, Kalpitiya, Nachchikkali, Marichchukkaddi and Delft. The 40 inch isohyets have been drawn on the new annual average map and the areas within the range (35-40) inches shown.

Details of the stations having annual average less than 40 inches are given below :

		(1911-40) average	(1931-60) average
1. Maha Lewaya (Hambantota Saltern)	..	35.90 inches C	.. 36.59 inches
2. Yala	..	36.23 .. C	.. 37.40 ..
3. Mannar	..	39.76 ..	.. 38.09 ..
4. Kalpitiya	..	40.30 .. C	.. 38.23 ..
5. Nachchikkali	..	39.41 ..	.. 39.18 ..
6. Marichchukkaddi	..	37.87 ..	.. 39.59 ..
7. Delft	..	43.18 ..	.. 39.88 ..

(b) Changes in the positions of the Isohyets on the Annual Average Map.

200 inch isohyet : Very slight change, the area receiving rainfall greater than 200 inches being slightly smaller, as the average for Theydon Bois Estate (Nawalapitiya) is now 193.98 inches.

150 inch isohyet : This encloses a larger area as it now includes Kanana Estate (Bentota) and Depedene Estate (Rakwana). However it excludes Yataderiya Estate (Undugoda) and Ruwanwella. The position of the other 150 inch isohyet encircling Hendon Estate and St. Martin's Estate, both in Nitre cave, remains unchanged.

125 inch isohyet : Slight change as this now includes Baddegama, but excludes Westward Ho Estate (Nuwara Eliya) and Sogama Estate (Pussellawa). The other isohyet which encircles the Nitre Cave-Madugoda area, and now includes Iddumekelle Estate (Madugoda).

100 inch isohyet : The position of this isohyet near the Haputale area has changed and now includes Blackwood Estate (Haputale). This isohyet excludes Polgahawela, Poramadella, Henaratgoda, Angoda and Moratuwa which were encircled by this isohyet on the earlier average map. The 100 inch isohyet near Diyatalawa encircling Lunugala, Udahena Div. (Poonagalla Group, Bandarawela) and Meeriabedde Estate (Koslanda) is now smaller. The other isohyet encircling the Nitre Cave-Madugoda-Rangala area now includes Woodside Estate (Urugala), while the isohyet encircling Keenakelle Estate (Badulla) and Mahadova Estate (Madulsima) remains unaltered.

75 inch isohyet : The position of the main 75 inch isohyet has not changed much, except that over the central region of Ceylon, it now excludes Bakamuna (Elahera) and Batalagoda Tank. This isohyet is important, since it has been adopted by some, as the boundary between the dry and wet zones of Ceylon. However, this is not the criterion adopted by the Department of Meteorology.

50 inch isohyet : The isohyet over southeast Ceylon is virtually unchanged, except that it now excludes Tanamalwila. Over northwest Ceylon, the 50 inch isohyet now excludes Battulu Oya and Akathimurippu and over the Jaffna peninsula it curves to the right below Kankesanturai and Point Pedro, as these stations have annual averages less than 50 inches.

40 inch isohyet : This is an isohyet which was not drawn on the earlier maps. It is indicated by broken lines. In the southeast, it encircles Maha Lewaya and Yala and in the northwest it encircles Mannar, Marichchukkaddi, Kalpitiya and Nachchikkali, all these stations having annual averages in the range 35 to 40 inches.

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(c) Stations with a marked change in the Annual Average (from the 1911-40 average to the 1931-60 average).

1. A drop of 10 inches or more.

There are 4 stations in this category, namely:—

Carney Estate (Ratnapura)	..	..	O.A. 228.75 inches C (25)
			N.A. 217.92.....,,
Minneriya	..	..	O.A. 74.03 „
			N.A. 62.89 „
Oonoogaloya Estate (Kotmalo)	..	..	O.A. 164.27 „ C (15)
			N.A. 148.35 „
Orwell Estate (Gampola)	..	..	O.A. 113.74 „
			N.A. 100.45 „

Note: O. A. and N. A. mean old average (1911-40) and new average (1931-60) respectively. C denotes that the data is a corrected value, as the data available was for a period less than 30 years. The figures within the brackets indicates the period.

The change in the average of Carney Estate has already been dealt with. In the case of Oonoogaloya Estate, the old average was a corrected value based on a 15 year period (1926-40), which could lead to an error. As regards Minneriya and Orwell Estate both the old and new averages were based on full 30 years data and some explanation is necessary. The rainfall at Minneriya for the 5 decades from 1911 are:

(1911-20)—Total rainfall for the decade	894.94 inches
(1921-30)—Total rainfall for the decade	690.37 inches
(1931-40)—Total rainfall for the decade	638.42 inches
(1941-50)—Total rainfall for the decade	589.16 inches
(1951-60)—Total rainfall for the decade	659.24 inches

It will be noticed that the rainfall during the decade (1911-20) is high in comparison with the other values. This was due to comparatively high rainfall being recorded during 1911, 1913 and 1914, the annual totals for these three years being 137.48 inches, 148.10 inches and 128.05 inches respectively. As a result the average 74.03 inches for the period (1911-40) was on the high side. The new average 62.89 inches for the period (1931-60) is more representative of the annual average rainfall.

The annual average rainfall at Orwell Estate has dropped from 113.74 inches to 100.45 inches. There appears to be a decrease in the annual rainfall at Orwell Estate from 1911 onwards. The rainfall for 5 decades from 1911, was compared with the rainfall for the corresponding decades at Mariawatta Estate (Gampola), which is close to Orwell Estate.

	<i>Orwell Estate</i>	<i>Mariawatta Estate</i>
Total rainfall for the decade (1911-20) ..	1093.11 inches	.. 1041.92 inches
Total rainfall for the decade (1921-30) ..	1187.80 inches	.. 1110.08 inches
Total rainfall for the decade (1931-40) ..	1129.37 inches	.. 1118.40 inches
Total rainfall for the decade (1941-50) ..	945.51 inches	.. 936.08 inches
Total rainfall for the decade (1951-60) ..	936.71 inches	.. (Station closed)

The decrease in rainfall at Orwell Estate is confirmed by the decrease in rainfall at Mariawatta Estate, and therefore the change in the average of Orwell Estate can be accepted. It was not possible to apply Double Mass Curve Analysis to check the variation in rainfall at Orwell Estate, due to lack of data from comparable neighbouring rainfall stations.

(ii) *A drop of 5 to 10 inches.*

There are 20 stations in this category, namely Ambepussa, Avissawella Hospital, Blackwood Estate, Dandeniya Tank, Galewala, Hakgala, Hapugastenne Estate, Helboda Estate, Henaratgoda, Hanwella, Ledgerwatta Estate, Lenavihare Estate Maradankadawela, Nalanda, Polgahawela, Ruwanwella, Sogama Estate, Sudupanawela, Theydon Bois Estate and Udamedura. Of these, ten have corrected values for the (1911-40) average. It would involve too much space to discuss each station separately, but such changes can be accepted particularly since most of the stations concerned are in the Wet zone.

(iii) *A rise of 10 inches or more.*

There are 4 stations in this category, namely:—

Depedene Group (Rakwana) ..	..	O.A. 140.90 inches C (10)
		N.A. 150.92 inches
Kabaragalla Estate (Maturata) ..	..	O.A. 125.83 inches C (20)
		N.A. 139.81 inches
Kellie Estate (Dolosbage) ..	..	O.A. 185.26 inches C (15)
		N.A. 197.13 inches
Weweltalawa Division (Halgolla Group, Yatiyantota) ..	O.A. 200.51 inches C (10)	
	N.A. 220.38 inches	

At all these stations, the averages for the earlier period were corrected values based on periods 20 years or less. The new averages are therefore more representative of the rainfall at these stations.

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(iv) A rise of 5 to 10 inches

There are 16 stations in this category, namely Digalla Estate, Elephant Pass, Gal Oya Anicut, Gonapenigala Estate, Gourakele Estate, Horaborawewa, Kanana Estate, Kanankadu, Kobonella Estate, Luccombe Estate, Mahawalatenna, Padupola, Panawa Tank, Pooprassie Estate, Puwarasakulam and Timitar Estate. Of these 7 have corrected values for the (1911-40) average. As stated before, such changes are acceptable.

2. SOUTHWEST MONSOON (MAY-SEPT.) AVERAGE RAINFALL MAP

The average rainfall over Ceylon during the southwest monsoon ranges from 3 inches to 143 inches. The new average map appears to show a decrease in the rainfall over many regions of the Island.

Changes in the position of the Isohyets.

Isohyet 120 inches: The area enclosed is now smaller, since Carney Estate and Ingoya Estate (Kitulgala) are excluded.

100 inch isohyet: No change.

80 inch isohyet: The area within the range 80 to 100 inches is now much smaller, since several stations in the south-western lowlands, such as Sirikandura Estate (Matugama), Gikiyanakande Estate (Neboda), Raigam Estate (Ingiriya) and Sunderland Estate (Eheliya-goda) now have averages less than 80 inches.

60 inch isohyet: The area enclosed by this isohyet too is smaller, since stations such as Hanwella, Dompe, Vincit Estate (Ruwanwella) and Pelmadulla now have averages less than 60 inches.

40 inch isohyet: Slight change. This isohyet now includes Campion Estate (Bogowantalawa) but excludes Alagalla, Kirimetiya Estate (Galaha), Colombo Observatory and Moratuwa.

20 inch isohyet: This is an important isohyet as it is the criterion adopted by the Department of Meteorology for defining the boundary between the Wet and Dry zones of Ceylon.* There are slight changes

5. DASSANAYAKE, D. T. E. (1948). Presidential Address Section E. Proceedings of the Fourth Annual Session, Ceylon Association for the Advancement of Science.

in the positions of this isohyet. Near the Maturata area it excludes Kurundu Oya and near Ganewatta, it excludes Flensburg Estate. There are two other 20 inch isohyets. The larger of these encircling the Passara area is now smaller, as it excludes Stratheden Estate (Ella) and Lunugala Division (Poonagalla Group, Bandarawela). The smaller isohyet encircling Blackwood Estate (Haputale) and Lemastota Estate (Koslanda) has disappeared, as these two stations have averages less than 20 inches. A small isohyet now encircles Geelong Estate (Monaragala).

10 inch isohyet : There is an appreciable change in the position of this isohyet over north-west Ceylon, as this isohyet now encloses a larger area of the North-central Province, the southwest monsoon rainfall at Kalawewa, Sigiriya, Pelwehera, Bakamuna and Minneriya now being less than 10 inches. The position of the other isohyet in the southeast has not changed much.

3. OCTOBER-FEBRUARY AVERAGE RAINFALL MAP

The rainfall taken into account in this map is not the average northeast monsoon rainfall, but the rainfall during the months October to February, which more or less comprise the Maha season. The average rainfall over Ceylon during these months ranges from 21 inches to 125 inches. There is no significant change in the rainfall pattern, except for the position of the 40 inch isohyet over the northern, northcentral and western regions of the Island.

Changes in the positions of the Isohyets :

Isohyet 120 inches : No change.

100 inch isohyet : A small additional isohyet now encircles Dooromadella Estate (Gammaduwa), but otherwise there is no change.

80 inch isohyet : Slight change in the isohyet encircling Keenakelle Estate (Badulla), but otherwise there is no change.

60 inch isohyet : Slight changes in the positions of the different isohyets, the areas enclosed being larger due to the inclusion of Sirikandura Estate (Matugama), Kokkawita Group (Kalawana), Eheliyagoda, Beausejoir Estate (Nakiyadeniya), Panilkande Estate (Deniya), Bibile and Horaborawewa. The smaller isohyets encircling Blackwood Estate, Unichchai and Watawala now disappear, as the

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rainfall at these stations is less than 60 inches. However, small isohyets now encircle Ingoya estate and Kanankadu. the average rainfall at these two stations being just above 60 inches.

40 inch isohyet : There is little change in the isohyet over southeast Ceylon, the only change being that Galle and Okkampitiya are now in the range 40 to 60 inches. The isohyet over the northern, north-central and western regions of the Island has changed its position appreciably, the area in the range 20 to 40 inches, now being much larger. This area now includes Point Pedro, Kankesanturai, Kayts, Puliyankulam, Vavuniya, Lenawihare Estate (Dodangaslanda) and Henaratgoda, but excludes Colombo Observatory, Maligakande and Angoda. There is little change in the other 40 inch isohyets over central Ceylon. The isohyet which encircles Elephant Pass remains unaltered.

CONCLUSION

It is a popular belief that rainfall over Ceylon has decreased, particularly in the Dry Zone. However, the comparisons of the three sets of average maps appear to show that there has been no significant change in the rainfall pattern over Ceylon from the 30 year period (1911-40) to the 30 year period (1931-60), although some changes were noticeable in the positions of the isohyets, particularly in the southwest monsoon average map.

Precipitation maps prepared using unprocessed rainfall data, will never be statistically accurate enough to express a scientific opinion on rainfall trends, unless there is a very high degree of reliability in all the data available. In the case of data from rainguage stations in Ceylon, it is found that the degree of reliability varies considerably, some with fairly high reliability and others with very low reliability. The rainfall data of every station used in the preparation of precipitation maps has to be examined for consistency. This is possible only by the Double Mass Curve Technique and rainfall values, wherever necessary, have to be adjusted to ensure that any trends detected are due to meteorological causes and not as a result of the change of location of a rainguage, faulty guage exposure or errors in observation. This is a task which can only be undertaken as a specific research project, with adequate staff and computer facilities.

It is, however, important to note that the Double Mass Curve Technique must be applied with caution, as a thorough knowledge of the reliability of the rainfall data at each station is necessary,

before adjustments are made. For instance, it would be incorrect to adjust the rainfall averages of the meteorological stations like Colombo Observatory, Galle, Hambantota, etc., by Double Mass Curve Analysis, using rainfall data from neighbouring raingauge stations, where the degree of reliability is considerably less than at the meteorological stations. In the publication "Hydrometeorology of Ceylon"¹ adjusted values have been prepared for the 50-year period 1907-56). Unfortunately, the recorded rainfall even at Colombo Observatory has been adjusted, which is incorrect, since the degree of reliability and accuracy of the recorded values of rainfall at this station is high. The 24-hour recorded rainfall at Colombo Observatory is checked against the readings on a spare raingauge and also against the rainfall recorded on a Casella Rainfall Recorder. In some instances, the recorded monthly totals have been adjusted by more than 10 inches, which can be misleading. A few examples are :

<i>Month/Year</i>		<i>Recorded Rainfall</i>	<i>Adjusted values in "Hydro- meteorology of Ceylon"</i>	<i>Difference.</i>
October	1932	.. 30.74	.. 16.18	.. 14.56
April	1953	.. 25.87	.. 12.09	.. 13.78
May	1932	.. 29.38	.. 16.26	.. 13.12
May	1940	.. 11.30	.. 24.00	.. 12.70
October	1930	.. 33.38	.. 22.08	.. 11.30

There are also many instances where the difference between the recorded and adjusted values is greater than 5 inches.

If rainfall trends are to be studied, precipitation maps have to be prepared using adjusted averages for two 30 year periods which do not overlap, such as (1911-40) and (1941-70). Maps prepared using adjusted averages for shorter periods, such as 10 year or 20 year periods, would give misleading results. It is only after an analysis of such maps for 30 year periods, that an accurate, scientific opinion can be expressed as to whether the rainfall over different regions of Ceylon has changed during the last 60 years and, if so, to what extent.

¹ Hunting Survey Corporation Report (1962) Part I. Rainfall and Runoff.